United States Department of the Interior
Bureau of Indian Affairs
Southwest Region
1001 Indian School Road, NW
Albuquerque, New Mexico 87104

TAKE PRIDE IN AMERICA

In Reply Refer To:
360-Tribal Government Services
BIA-2018-00091

CERTIFIED LETTER

OCT 13 2017

Cynthia Howard
P.O. Box 140873
195 North 1820 West
Salt Lake City, Utah 84114-0873

Dear Ms. Howard:

On October 11, 2017, the Bureau of Indian Affairs (BIA), Southwest Regional Office (SWRO) received your Freedom of Information Act (FOIA) request dated October 5, 2017, and assigned it control number **BIA-2018-00091**. Please reference this number on all future correspondence.

You requested the following:

> "Task 5 Final Report December 16, 2016.doc with Appendix 5B Introduction to the Use of Uranium and Radium Isotopes in Geochemical Forensic Studies.doc, Appendix E UMUT and EFR Trip Report November and December 2016.doc, Figure 1 Roadmap Level 1.doc, Figure 2a to 2c Flow Chart for GWCL Modification and Challenges by the UMUT EDP.doc, and Tables 1 to 4.doc."

We have classified you as an "other-use" requester. As such, we may charge you for some of our search and duplication costs, but we will not charge you for our review costs; you are also entitled to up to 2 hours of search time and 100 pages of photocopies (or an equivalent volume) for free, *43 C.F.R. § 2.39*. If, after taking into consideration your fee category entitlements, our processing costs are less than $50.00, we will not bill you because the cost of collection would be greater than the fee collected, *43 C.F.R. § 2.37(g)*.

We are writing today to respond to your request on behalf of the BIA, SWRO.

We have enclosed 78 pages, which are being released to you in its entirety.

We do not bill requesters for FOIA processing fees when their fees are less than $50.00, because the cost of collection would be greater than the fee collected, *43 C.F.R. § 2.37(g)*. Therefore, there is no billable fee for the processing of this request.

This concludes our response to your request. Should you have any questions regarding this response, please contact Jean Buck-Curtis, FOIA Coordinator at (505) 563-3543, or email, Jean.Buck-Curtis@bia.gov.

Sincerely,

Regional Director

Enclosure

REVIEW OF DOCUMENTS FROM WHITE MESA URANIUM MILL

FINAL REPORT - TASK 5 DELIVERABLE

Executive Summary

A review of reports and memos written by contractors to the operators of the White Mesa Mill (currently Energy Fuels Resources (USA) Inc (EFR), the Utah Department of Environmental Quality (UDEQ) and the Ute Mountain Ute Tribe Environmental Programs Department (UMUT EDP) concerning potential environmental effects from the Mill has been carried out. The numerous concerns raised by the UMUT EDP can be divided into a few major topics related to potential future health effects:

1. Tailing cells are currently leaking and have produced a multi-component plume that has been detected in several monitoring wells as indicated by decreasing pH and increasing concentrations of several other solutes.
2. Air blown dust from ore transport trucks and ore storage pads has contaminated surface water and land areas to the east and northeast of the Mill.
3. Radon emissions from tailings cells exceed limits that are protective of human health.
4. Remediation of the effects of the above will be more costly than previously estimated and the surety bond held in trust for the cleanup is insufficient.

The scope of the current contract and expertise available to LJS Consulting, Inc has necessitated primary focus on item 1 above, preliminary evaluation of items 2 and 3 and a cursory review of item 4.

Based on review of the documents examined to date, it is concluded that:

1. The available information suggests that observed pH decreases and increase of metals concentrations in wells down gradient of the tailings cells are not necessarily due to tailing cells leakage.
2. The leaks and repairs reported for Legacy Tailing Cells do not suggest that the cells are not operating as designed. It cannot be stated that the tailings cells will not leak in the future due to poor design, however, if they do leak, then reactive transport modeling (ICTM) carried out so far suggests that a plume will not reach the aquifer within the 200 year regulatory period. It would be useful to run the ICTM for at least 1000 yrs; the model is a useful tool for sensitivity analysis, which should be done with input from the Tribe (as well as the State).
3. The available information suggests that air blown dust from the facility may have led to levels of uranium concentration in Entrance Spring and stream sediments that are above background levels. However, the alternative model proposed by EFR that the contamination is from historic operations not associated with current Mill activity is also

plausible and should be examined in more detail. Concerns about inadequate air sampling procedures might be resolved by review of the maintenance records for the High Volume Air Samplers.

4. Radon emissions from the tailings cells may have been overestimated by the UMUT EDP staff due to improper model assumptions. Another potential hazard might be indicated by odors detected by residents; plumes coming from the facility are observed and reported anecdotally.
5. The impact on human health of reasonable worst-case scenarios involving the effects described in items 1 to 4 above should be evaluated in a systematic risk assessment that involves consideration of exposure pathways, epidemiologic data, sensitivity analysis and community participation. Evaluation of the sufficiency of the surety bond should be evaluated in light of such a risk assessment as well as cost analysis based on other similar sites.
6. Communication between the Tribe, State and Federal Regulatory Agencies can be improved by sensitivity to cultural issues. The Bureau of Indian Affairs can play a valuable role in providing assurance to the Ute Mountain Ute Tribe that the concerns of the Tribe are being reviewed and carefully evaluated.

As evidenced by the numerous Requests for Agency Actions (RAA) filed by the UMUT EDP, it is clear that there is no simple way to resolve the areas of uncertainty and satisfy the concerns of the Tribe with respect the long-term risk posed by the Mill facility. There is a large number of complex technical issues that are important and a team of experts would be required to provide a comprehensive evaluation of these issues. However, it is suggested that the Bureau of Indian Affairs could act as an impartial party in bridging some of the gaps in the positions held by the Tribe and the Mill owner. Several possible activities are suggested below that might add additional data to reduce uncertainty, mitigate potential risks and create more trust between the stakeholders.

1. Complete the analysis of potential role of pyrite oxidation as cause of pH decreases and metal concentration increases in monitoring wells by measuring additional redox couples in groundwater and more fully characterizing pyrite and iron oxide occurrences in unsaturated zone. Additional PHREEQC modeling incorporating rate constants for important reactions could be used to assess short-term effects associated with well-purging.
2. Address concerns about wind borne contamination by better monitoring of radon sources and wind velocity.
3. Address UMUT EDP concerns about Mill work practices including sampling and analysis procedure by carrying out verification exercises with an independent laboratory.
4. Look at alternative conceptual models for the Integrated Contaminant Transport Model
5. Consider additional tracers such as isotopes for fingerprinting potential leaks from tailings cells and setting Ground Water Compliance Limits.

6. Allow the installation of 3 new wells as suggested by EFR to be placed in the perched zone to characterize groundwater flow and direction in the area between MW-17 and MW-22.
7. Carry out risk management analysis within framework of Monitored Natural Attenuation to address concerns about long term risk.
8. Use the method developed by DOE's Innovative Technology and Remediation Development program to get a consensus about what additional steps are needed to be taken to evaluate potential leaks and off-site transport of radionuclides.

Introduction: Overview and history of contract

Summary Timeline for Contract

Date	Activity
December 20, 2014	Colin Larrick (UMUT EDP) provides document package to Chris Banet at BIA
June 11, 2015	Initial contact between LJS Consulting and BIA (Tony Zimmerman) to discuss potential contract with BIA
July 2, 2015	LJS Consulting receives UMUT package document and proposal is submitted
April 4, 2016	Contract with LJS Consulting, Inc. is placed
June 6, 2016	Completion of Task 1 - Initial Document Review
July 20, 2016	Telecon with Colin Larrick of UMUT EDP and receipt of first set of new documents (see Attachment A)
July 26, 2016	Completion of Task 2 - Draft Report Outline
September 22, 2016	LJS Consulting visit to UMUT EDP offices in Towaoc and White Mesa Mill Site (see Attachment B)
October 14, 2016	Telecon with Harold Roberts, EFR (see Attachment C)
November 2, 2016	Receipt of new documents on Rn monitoring from EFR
November 14, 2016	Submittal of Task 3 Draft Report to BIA
November 22, 2016	Project review meeting at BIA offices
November 30, 2016	Project Review Meeting at UMUT EPD in Towaoc, CO
December 1, 2016	Project Review Meeting at White Mesa with EFR staff
December 1-2, 2016	Sampling of off-site wells by Duke University student
December 15, 2016	Final project review meeting with BIA staff
December 22, 2016	Submittal of Task 5 Final Report to BIA

Document Review Process

This contract began on April 4, 2016 with the review of documents provided by the Ute Mountain Ute Tribe Environmental Programs Department (UMUT EDP) through the Bureau of Indian affairs. Approximately 70 documents comprised of more than 10,000 pages of data and analyses were included in the data package received from the UMUT EDP. Under Task 1, an initial document review was carried out in an attempt to identify which documents (Level 1 Documents) defined the most important issues and which documents provided supporting information. To do this, this initial document review identified the relationships between the documents, identified the major regulatory actions and subjects important to this work, and established a timeline describing the evolution of the regulatory and technical activities.

Regulatory actions include applications for the license for radioactive materials, groundwater discharge permits, corrective action plans, air quality permits, and site closure plans. Documents supporting these actions are submitted by the owner of the facility to the Utah Department of Environmental Quality (UDEQ) . After submittal of the documents, the staff at

UDEQ reviewed them and most often sent the document back to the mill Site owner with a requests for additional information. A public review process allowed members of the community to provide their comments on the adequacy of the submittals. After review of these comments and submittal of revised versions of the original documents, the regulatory action was completed by granting a license renewal or a water or air quality permit etc. In general, the UMUT EDP submitted RAA (Request for Agency Actions) or other challenge to the Utah courts based on their conclusions that the community participatory process was not adequate and the current license and permits are not adequately protective of the health of the Tribe members who live in nearby community of White Mesa.

Figure 1 is a Roadmap that describes the relationships between the most significant actions of the Site owner, Regulator and the Ute Mountain Ute Tribe Environmental Programs Division (defined as Level 1 in this report). Table 1 describes these Level 1 documents which include the Requests for Agency Action that have been filed by the Tribe. The RAAs are based on Exhibits that contain the technical justification of the challenges made by the UMUT EDP. Tables 2 and 3 describe the Exhibits for the RAAs concerning the Nitrogen Corrective Action Plan (dated 1/11/2013) and the Approval Order of March 3, 2011 (dated 3/31/2013) respectively.

Both Figure 1 and Table 4 also include an description of the main comments provided by the Tribe regarding the Denison Mines USA Radioactive Materials License Renewal application of 2011 (referred to as 'UMUT Searchable Comments Letter'). This Level 1 document contains a comprehensive description of the Tribe's concerns. An outline of the document in MS Word Outline View is provided as Appendix 1 to this report. It describes the supporting information contained in the Exhibits and also legal exchanges between the Tribe, the Utah Department of Environmental Quality, and the Site owners. Table 4 describes the author, recipient, main points and important references cited by the Exhibits in this document. Many of the same documents are relevant to the RAA concerning the Dawn Mining Alternate Feed Amendment Request (dated 8/11/2014).

Task 2 of this contract involved detailed document review and preparation of the outline for the Draft Report. Document Roadmaps were prepared for major technical/regulatory areas identified under Task 1. The documents were classified into the groups (Level 2) for the purpose of constructing the Roadmaps which showed how they were related in both subject matter and history:

- Radioactive Materials License Renewal (Table 4)
- Air Quality Issues

- Nitrate Corrective Action Plan (Nitrogen CAP) (Table 2)
- Ground Water Discharge Permit (GWDP) (Appendix 2)
- Integrated Contaminant Transport Model (ICTM) (Appendix 2)
- Source Assessment Reports (SAR) (Appendix 3)
- Ground Water Compliance Limit (GWCL) Modifications and Pyrite Dissolution Studies (Appendix 3)
- Ground Water Background Reports (Figure 2c)
- Tailings Cells Reports (Appendix 4)

In the list above, Level 2 documents are ordered to show subjects with more data at the bottom and more integration at the top. In many cases, the same document contained technical data that supported one or more subjects and there was overlap in the data used by more than one Level 2 subject.

Appendices 2 to 4 describe how different documents are related to Level 2 subjects . Figure 2a to 2c describe how Groundwater Background Reports and modifications to the Ground Water Compliance Limits (GWCL) are related. Figure 2c describes the interactions between the Tribe, Site owner and DEQ in revising the GWCLs. These appendices, tables and figures were compiled prior to detailed review of the documents in order to keep track of the tremendous amount of information relevant to the White Mesa Mill. They provide the foundation for the current and any future work in this contract.

Background Information about the Site

The Ute Mountain Ute Tribe is a federally-recognized Indian tribe with lands located in southwestern Colorado, northwestern New Mexico, and southeast Utah. There are two Tribal communities on the Ute Mountain Ute Reservation: Towaoc, in southwestern Colorado, and White Mesa, which is located in Utah within three miles of the White Mesa Mill ("WMM") facility. The lands comprising the White Mesa community are held in trust for the Tribe and for other individual Tribal member owners. Over the course of the last 30 years, the White Mesa uranium mill has been managed by several companies including Uranium Fuels, Denison USA, and its current owner, Energy Fuels Resources.

Currently the mill site includes five tailing cells which contain both liquid and solid wastes from the operations of the mill facility or other materials that have been sent to the facility for disposal. The tailings cells sit within the Burro Canyon Formation. The water table lies above the contact with the underlying Brushy Basin Member of the Morrison Formation. The thickness of the perched saturated zone has an average of about 35 feet; there are several springs along the edge of the Mesa. The springs are used by livestock that roam the Mesa and perhaps by members of the Ute Mountain Ute tribe. At one of the springs (Entrance Springs), willows and other plants grow within a small canyon.

As part of normal operating procedures, the owner of the mill is required to monitor water and air quality in areas surrounding the mill facility. Approximately 30 monitoring wells have been drilled into the Burro Canyon formation, which contains a perched water aquifer. Water samples from these wells are analyzed for 38 chemical constituents. Maximum allowable concentrations (Ground Water Compliance Limit (GWCL)) have been set for each of these constituents in each of the wells that are based on a provisional background concentration and considerations of protections of public health. The wells are sampled on an annual basis as part of the standard procedure. Concentrations of four chemicals (chloride, pH, uranium, and nitrate) are routinely measured. These constituents are considered to be leading indicators of any potential leak from the tailing cells because they are present in high concentrations in the cells and are considered conservative tracers. If any of the chemical constituents exceeds the GWCL for more than two consecutive sampling events, then an out of compliance (OOC) condition is declared and the well must be sampled on a quarterly basis. In addition, a Source Assessment Report (SAR) must be prepared by the site owner to evaluate if the OOC is due to the release from tailings cells. The evaluation includes examination of trends in concentration of each of these constituents over time and mass balance calculations to see if the increase in concentration is consistent with concentrations in the tailing cells and mixing volumes of leakage with groundwater. The background concentration of the constituent is calculated on an ongoing basis from the available time series of concentration. The Department of Environmental Quality follows an EPA procedure to evaluate any trends in concentration over time. This procedure allows for the increase of the GWCLs if it is determined that the available data are consistent with such an increase in the estimated *background* concentration. The adjustment of the GWCL is often contested by the UMUT EPD when the site owner has applied for a renewal of the groundwater discharge permit for the site. The Tribe has argued that this procedure will allow potential leakages from the tailing cells to be undetected. Of particular concern is the decrease in pH and concommitment increase in concentrations of several metals in some of the monitoring wells. The site owner has argued that the decrease in pH is due to dissolution of pyrite in either the unsaturated or saturated parts of the Burro Canyon and is not related to any leakage from the tailing cells. Evaluation of this variation in pH and other groundwater solutes due to natural variation is a key element of this review. There is disagreement over whether to include additional indicator solutes in routine ground water quality measurement in the monitoring wells. Discussion of the use of new indicators such as radium isotopes is included in this report.

The Tribe has argued that the liners in the legacy tailing cells are passed their expected lifetime and that leakage is inevitable. In addition they maintain that the leak detection system will not detect any leaks before a contaminated plume reaches the aquifer. The site owner has used a reactive transport model to calculate how far a potential plume could travel during the 200 year regulatory period. According to these calculations, based on realistic failure modes for the liner, groundwater velocities in the unsaturated zone, and the geochemical reactions between uranium and rock matrix, a potential plume will not reach the aquifer during this period. The Tribe has challenged the assumptions of this transport model. In particular, the Tribe feels that the model does not account for potential fast paths in the aquifer or properly describes the

chemical speciation of uranium and sorption capacity of the rock matrix. The Tribe has argued that their interpretation of rising concentration trends for uranium, pH and other metals demonstrates that the cells are leaking and a contaminant plume is spreading more rapidly than the site owner has maintained. Discussion of the adequacy of this reactive transport model is discussed in this report.

The material that is shipped to the mill for reprocessing comes in a variety of forms including uranium mill tailings, residues from treatment plants, and other radioactive waste forms. Of particular concerns are the dust and fine particulates associated with the uranium mill tailings. These are shipped in large trucks along the highway and until three years ago the ore was not covered. This material sits on pads at the facility until a sufficient amount is received to justify operating the mill. There is evidence collected by the USGS and the Tribe suggesting that uranium-containing dust is blown from the mill to the surrounding area. Relatively high concentrations of uranium and vanadium have been measured in soils, water, and plants that lie along dominant wind paths and in the ephemeral stream drainage basins that are connected to Entrance Springs and several monitoring wells.

Focus on Current Concerns of the UMUT EDP

There are many concerns raised by the Tribe (see Appendix 1) that have not been addressed in this report due to limitations in the size of this contract. Conversations with UMUT EDP and the Site owner identified the most current concerns, and efforts in this contract have focused on these issues. A teleconference with UMUT EDP staff was held on July 21, 2016 (Appendix A); a field trip was taken to White Mesa on September 22, 2016 (Appendix B) and a teleconference was held with staff from Energy Fuels Resources on October 14, 2016 (Appendix C). In addition, a report written by a contractor to the Tribe (Geol-Logic Associates, Inc) and the review of the report prepared by the Utah Department of Environmental Quality were provided by the Tribe. A discussion of the main points in the report and the Utah DEQ comments are found in Appendix D. Based on these interactions and the data reports described in Tables 1 to 4 and Appendices 1 to 4, the key technical issues were identified for this report. These are described in the following sections as a series of questions; analyses of the technical issues and recommendations follow. After the Draft Final Report (Task 3) for this project was submitted to BIA, UMUT EDP and EFR staff, meetings were held with the stakeholders at the BIA office in Albuquerque, NM, at the UMUT EDP office in Towaoc, CO and at the Mill Site in White Mesa for review of the initial findings. In addition, a site visit at the Mill allowed me to view the tailing cells, Mill and ore holding areas (see Appendix E) . This Final Report (Task 5) was prepared after these meetings.

Key Technical Questions:

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1. ***What are the most reliable indicators of potential leakage from the tailings cells?***

2. ***Is transport of contaminants from leaking tailings cell to perched aquifer rapid enough to threaten health of potentially exposed populations?***

3. ***Could such a multicontaminant plume persist in the environment for many generations, constituting an incalculable risk?***

4. ***What is the importance of airborne releases of radionuclides and deposition on plants to overall radiological dose to the population in the area?***

Detailed Discussion of Key Questions

1. ***What are the most reliable indicators of potential leakage from the tailings cells?***

- UMUT EPD asserts that observed decreases in pH and increases in metals concentrations in several wells down gradient from the tailings cells indicate leakage from the tailings cells.
- UMUT EPD does not accept the method used by EFR (and accepted by Utah UDWMRC) to set acceptable concentration levels in each of the monitoring wells (GWCLs). (see Figure 2b). These levels are assumed by EFR to represent background concentrations of key indicator solutes or waste components and as such are used to monitor for any possible contaminant releases from the cells. Over the last few years these levels have been rising in several monitoring wells. EFR argues that these changes are due to natural background variations and the GWCLs should be adjusted as additional data describing these variations are obtained over time. However, UMUTDP rejects this approach, argues that it masks the actual trend of rising concentrations and that the GWCLs should not be continually adjusted and allow EFR to avoid taking action to prevent or monitor further (potential) leakage.
- UMUT EPD feels that there are very limited reliable data to establish the background concentration of potential tracers and contaminants at the site. Many data collected in surveys before the Mill started operations have been rejected due to poor QA/QC procedures.
- UMUT EPD also feels that the suite of solutes measured in monitoring wells and relied upon as early indicators of cell leakage is no longer adequate. Two of the indicators (chloride and nitrate established in 1996) are now of limited use because of alternate and historical sources for these solutes (ammonium sulfate and chloroform plumes). A Corrective Action Plan is designed to control nitrate, and Cl and NO3 have lost their "canary in the coal mine" value near the cells.
- UMUT EPD argues that additional indicator solutes (besides Cl, NO_3, U , SO_4, U and pH) should be measured routinely at points of compliance wells and that additional wells such as MW-22 should be designated at compliance wells. Many of these additional solutes would not be conservative tracers.

- UMUT EPD feels that a review of the potential retardation of new (nonconservative) indicator solutes is required but must be done on a site-specific basis. (Simple generic K_ds from the literature would not be sufficient).
- UMUT EDP feels that the Legacy Tailing Cells are beyond their design life and were built according to standards that are now know to be inadequate. This supports their view that the observed trends in pH and metals concentrations are indications of past and current leakage.

Analysis: 1) Review of Geochemical Forensic Studies of Ground Waters

Two evaluations of geochemical forensic evidence relating to potential existence of contaminant plumes emanating from the tailing cells have been carried out. They are described in detail in Appendix 5A and summarized briefly below. Hurst and Solomon (2008) examined isotopic and trace metal signatures of several wells on the Mill Site (MW-1, 1B, 2, 3, 3A, 5, 11, 14, 15, 18, 19, 22 , 27, 29, 30, 31), Tailings Cells 1, 2 and 3, and Wildlife ponds (WP2 and WP3). The US Geological Survey (Naftz et al. 2011) examined similar isotopic and metals signatures for a complementary set of wells and water sources outside of the Mill site. Table 1 in Appendix 5A compares the sites evaluated and the interpretations presented for both studies.

In general, the conclusions of the two studies are similar. Both studies conclude that it is unlikely that elevated and increasing concentrations of uranium or other solutes observed in several of the wells were related to leakage from the tailings cells. This was based on the fact that 1) the isotopic signatures for oxygen and sulfur in aqueous sulfates in the wells are very different from those in tailings cells, 2) with the exception of MW-19 and MW-27, oxygen and hydrogen isotopes of water in those wells data do not indicate mixing between evaporated, enriched surface water (from either the wildlife ponds or the tailings cells) and isotopically lighter groundwater. In addition, the USGS study showed that the $^{234}U/^{238}U$ Activity Ratio for all samples with U concentrations< 30 mcg/L range from 1.4 to 3.4, suggesting natural source for the uranium. The $^{235}U/^{238}U$ Activity Ratio also suggested a natural source for the uranium in all wells and surface water sources sampled. However, very few sources were sampled on the Mill site for this study. In absence of such data, the UMUT EDP has challenged the Site owners conclusion that there is no possibility of WMM-caused pollution of the wells because of the distance from the facility.

Both studies suggest potential transient effects in the future. The studies indicate that the shallow groundwater system is dynamic due to the presence of the wildlife ponds that recharge the shallow aquifer and that changes in metals concentrations in the wells are likely to continue to be observed without any leakage from the tailings cells. The presence of CFCs and the absence of tritium in some waters suggests it takes infiltration water longer than 50 years to travel through the vadose zone. The system away from wildlife ponds can be considered recharge-limited and not permeability-limited. Active groundwater flow occurs vertically and

horizontally, and if leakage from tailing cells occurs in the future, a contaminated plume is likely to reach the water table.

Recommendations for additional forensic studies:
According to the UMUT EDP, there have been many changes in the site hydrology and geochemistry since completion of the USGS study (Naftz, 2011). Many new monitoring wells are in place, the flow system at the site has changed due to cessation of filling the wildlife ponds and the initiation of corrective action for the nitrate plume, and advances in isotope geochemical techniques have been made in the last 5 years. It is therefore recommended that:
1) the suggestions made by the USGS after the completion of their study be followed. These included:

- additional use of uranium isotope ratios to evaluate source of uranium in monitoring wells, dust and sediments, and
- use of sulfur, hydrogen and oxygen isotope studies of springs, additional wells and ponds to determine sources of waters samples in wells near the UMUT Reservation such as MW-22.

2) EFR work with Duke University, the UDEQ and the UMUT EDP to evaluate the use of additional forensic tracers such as radium, boron and lithium isotopes and metal ratios. The use of radium isotopes is described in Appendix 5B and publications cited therein (see also Bryan et al. 2012).

Analysis: 2) Dissolution of pyrite and 'natural variability' model.

The Site owners have argued that dissolution of pyrite is the cause for increase in acidity and metals concentration at monitoring wells. The Site owner has measured iron concentration as well as pyrite occurrence in a large number of wells in a way that provides some confidence in their assertion that pyrite is present in sufficient amounts to supply acid to decrease pH and mobilize metals. The UMUT EDP has based its objection to the 'natural variability model' on the argument that insufficient oxygen is present in ground water to oxidize the pyrite and that all of the pyrite in the unsaturated zone has already been oxidized (see Appendix D.)

Recommendations:
Oxygen partial pressure is not the best parameter to characterize the redox potential of an aquifer. Other redox couples could be measured in the groundwaters and a more site-specific model for oxidation of pyrite could be proposed. In addition, the sampling strategy used by the site owner should be described in a way that demonstrates that a statistically valid sample has been taken. The distribution of pyrite in the vadose and saturated zones could be characterized more completely. Core samples from the unsaturated zone could be examined to estimate the distribution of pyrite (and iron oxide). Information about large scale features within the Burro Canyon that might lead to preferential fast paths should be incorporated into this description. The Site owner has suggested that the redevelopment of many wells since 2011 leads to introduction of oxygenated water into the saturated zone and oxidation of the pyrite. The rate of pyrite oxidation could be limiting factor situation. A kinetic chemical speciation model could be used to determine if this is a realistic scenario. The role of microbes in pyrite oxidation

should also be considered since this would increase reaction rates. Several computer codes are available that for closed system simulations including PHREEQC. It has been suggested (Nordstrom et al. 2007) that the oxygen and sulfate isotope signature of sulfate might be used to determine if pyrite oxidation is primarily controlled by oxidation by ferric iron from water or by oxygen from air. Measurement of these isotopes in waters from wells with decreased pH and comparing the isotopic signature to waters from the tailings cells and to wells where the pH decline has not been observed might be useful. The utility of this approach will depend on the relative contributions of sulfate from several sources including dissolution of gypsum as well as oxidation of pyrite.

Analysis: 3) Procedure used to set Ground Water Compliance Limits (GWCL)
The debates over the key indicators and the "natural variability" hypothesis enter the regulatory sphere through the procedure used to set the Ground Water Compliance Limits for each monitoring well. The Tribe argues that the GWCL (Ground Water Compliance Level) flow chart used by the Site and the State to set Compliance Levels for metals at the monitoring wells is not same as the EPA procedure upon which it is based. Specifically, they claim that it doesn't have an "off ramp" to force a outcome other than raising the GWCL. Examination of the chart from ~~Intera~~ INTERA publications (eg. INTERA, ~~2007~~2010) confirms that this is true, however EFR claims that the flow chart does have an "off ramp" that leads to a CA (Corrective Action). When an OOC (Out of Compliance) condition happens, the Source Assessment Report is required and that will lead to the either CA or a change in GWCL.

EFR feels that two accepted lines of evidence are used to justify raising the GWCL: the Utah isotope study that says there is no leakage from cells and the pyrite oxidation 'natural variability' hypothesis. The Tribe has argued that insufficient pyrite oxidation could occur to lower the pH because there is not enough oxygen in the saturated aquifer. EFR argues that the oxygen in saturated zone waters comes from stressing the wells. When they purge the wells, the cone of depression allows air to mix with the water. The wells are screened above the water line.

The State has accepted this as a "reasonable" idea. The main observations that support this are:

- the decreases in pH are observed site-wide; effects in MW 18 (which is upgradient) and MW-3 (down-gradient) are the most pronounced. The differences in the observed effect at different wells might be due to changes in water levels which lead to changes in the residence times of water along the flow path to the wells.
- the chloride plume is not seen upgradient where the pH is also decreasing.

The Tribe has countered with the following arguments: 1) the trends in pH and metals concentrations observed in upgradient wells are consistent with the groundwater mound observed near the Mill and 2) chloride is not a good indicator of leaking tailings cells because it can be adsorbed by clays in the liners system or bedrock.

The EFR staff feel the current procedure for setting the GWCLs is too conservative. The State forces reevaluation of the GWCL every time there is an OOC, whereas the company would like to have the GWCL revised every five years during license renewal. They would like to use the calculated temporal trends in pH and metals concentration to calculate the future GWCL that would be expected at that time. The State does not allow this and forces the company to do a Source Assessment Report based on the previous GWCL.

Recommendations:
1. It would be useful to review the Ground Water Discharge Permit to see how Corrective Action is triggered.
2. Although it is generally assumed that chloride is a conservative tracer, a literature review should be conducted to identify relevant conditions under which this assumption is false.

Past leakage from Legacy of Tailing Cells as indication that the cells are beyond their design life

In Exhibit H (Smith, 2011) of the Comments Regarding Denison Mines (USA) Corp Radioactive Materials License Renewal (Hawkins et al. 2011), UMUT EDP presents arguments that the design of the Legacy cells no longer conforms with current practice and that they have passed their design life of 30 years. During 2009, a leak was detected in Cell #1, which led to extensive repairs. The Tribe thinks that this leak was catastrophic and demonstrates that the cell linings are failing. When the leak occurred, the Mill dropped the liquid levels in the cell and photographed the damage beneath the liquid level. In the Tribes view, this shows that the cell lining failed and the damage was not simply due to sunlight exposure. The Tribe asserts that observed leaks demonstrate that that they leaking routinely, and must be replaced.

The Company has a different story: they feel that the leak detection system, although not as sophisticated as that in the newer cells (#4a,4b) worked as designed and indicated that there was (a small volume?) leak at a certain level. The Cell was drained below that level and they couldn't find the leak so they just replaced a huge section of the liner with new materials. They then refilled the tailings cell and there was no more leakage.

Because the waste at the site is a byproduct of uranium tailings (11e2 waste), the site will be closed permanently at some time in the future. The Site Reclamation plan requires that Cell #1 be dug up and material placed in a newer cell for final closure at some time in the future. The Site owner must clean all contaminated soils and put them in the tailing cells, including dust in the area from all around the Mill. Then the site becomes a DOE Legacy Site with a 1000 year cover, no active maintenance and is supported by a Perpetual Care Fund.

2. ***Could transport of contaminants from leaking tailings cell to perched aquifer be rapid enough to threaten health of potentially exposed populations?***

Review of Revised Infiltration and Contaminant Transport Model (ICTM)

Introduction- The purpose of the Infiltration and Contaminant Transport Model (ICTM)
The ICTM was developed to demonstrate the long-term ability of the tailings cells cover system to adequately contain and control tailings contaminants and protect the groundwater quality of the uppermost aquifer. The ICTM was required as part of Groundwater Discharge Permit application. Specifically, it supported Denison Mines (USA) Corp.'s Ground Water Discharge Permit (Permit No. UGW370004 revised version dated 20 January 2010).

A brief review of the results and the issues raised in review of the Infiltration and Contaminant Transport Model are presented below. More details are found in Appendix 6 (Summary of Issues Raised in Review of the Infiltration and Contaminant Transport Model (ICTM)).

Main Model Results and Issues

1. *Model-Predicted Uranium Concentration:* Uranium does not reach the bottom of the vadose zone beneath Cells 2 & 3 during the 240-year transport timeframe. Adsorption of uranium onto the surface of HFO present in the bedrock vadose zone limits the transport distance below the liner. The depth at which the uranium concentration is approximately equal to the minimum GWCL (0.0049 mg/L) is 2.3 meters (8 feet) below the liner system; a minimum of 10.5 meters (34 feet) above the perched water table. Transport of the following trace elements was modeled: arsenic, cadmium, copper, nickel, vanadium, and zinc. These solutes were also predicted to migrate only a few meters below the liner.
2. *Sensitivity analysis:* Three values for several model parameter were selected for sensitivity analysis; 3 scenarios- lower bound; base case and upper bound were identified. Input variables incorporated into the sensitivity analysis included: 1) the source term solution chemistry of the tailings pore water, 2) the maximum tailings saturated thickness during operations, 3) the number of potential liner defects, 4) the acid neutralization potential of the bedrock (ANP) vadose zone, and 4) the partial pressure of carbon dioxide gas within the bedrock vadose zone. For the upper bound scenario the depth at which uranium approximately equaled the minimum GWCL was 3.9 meters (compared to the base case of 2.3 meters)..
3. *Conservative nature of model assumptions:* Many of the model assumptions can be considered conservative in that they would tend to lead to overestimation of the transport of uranium. These include: , 1) failure to include precipitation of gypsum and iron oxyhydroxides as potential sinks for uranium, and 2) low estimates of the hydraulic head in the tailing cells. The Site owner claims that the failure to include the presence of naturally occurring uranium or other competing solutes in the aquifer is also a conservative assumption but doesn't explain why this is so.

Review by DRC

URS Professional Solutions reviewed the ICTM under contract to the Utah DEQ and requested additional information, changes or corrections to a large number of items in the model report (Round 1 Interrogatory). These issues were divided into the following topic areas: 1) inconsistencies between the model and the revised reclamation plan, 2) comparisons of the cover designs, sensitivity analysis, bathtub analysis, and radon emanation modeling, 3) moisture storage capacity of the cover, 4) evaluation of flow through the tailing cell liners, and 5) contaminant transport modeling.

The responses by EFR to these requests are not available at this time. However, the URS review appears to raise reasonable questions about the long term stability of the cover design proposed by EFR. None of these questions, however, would appear to be fatal flaws in the design and it is likely that EFR and the Utah DEQ will be able to reach an agreement on how to satisfy these questions. Questions about the bathtub analysis involved detailed discussions of geomechanics that are outside the scope of this work and are not discussed further. Similarly, questions concerning the reclamation plan such as types, amounts, sources, methods of application, estimated cost, and limitation of potential soil amendments are outside the scope of this review. URS requests additional sensitivity calculations to bracket a wider range of parameters used to evaluate flow through the tailings cell liners. Although this subject is outside the scope of this reviewer's expertise, such calculations do not seem to be unreasonable. Finally, the URS review requests additional data from new wellbores to better characterize the potential occurrence and distribution of fractures and on some on cemented higher permeability intervals along the flow path from the potentially leaking tailing cell and the aquifer. In addition, the reviewers request corrections to the statistics for two important geochemical parameter ranges, namely the amount of hydrous ferric oxide and the acid neutralization potential. The request to correct these ranges and new calculations for the purpose of sensitivity analysis also seen reasonable. A full description of these issues is contained in Appendix 6 (Outline and Summary of Issues in Review of the Revised Infiltration and Contaminant Transport Model).

Review by UMUT (Geol-Logic)

Although not directly reviewed in the Geo-Logic report, that report appears to take exception with the acid neutralizing potential and sorption potential of rocks assumed in the model that are present along the flow path to buffer the pH and to absorb uranium and other metals should they be released from the tailing cells. In addition, although the ICTM is a one-dimensional reactive transport model that only addresses transport from the tailings cell down to the aquifer, the questions that both Geo-logic and Utah Department of Environmental Quality raise are relevant to the question that appear to be most important, i.e. down gradient migration of tailings cells contamination that could ultimately reach the UMUT Reservation.

Current relevance of the ICTM in regulations:

During the Site visit on December 1, the purpose and relevance of the ICTM for long term performance was clarified. This model was specifically used in support of cover design and is

not expected to predict site wide contamination. The 200 year modeling duration was chosen to be consistent with the Atomic Energy Act Appendix A for tailings which require 200 year minimum life but a 1000 year design life. The discussions with the State have moved beyond discussions of the model because EFR has started a real test in Cell #2, which is in the first phase of reclamation. A test section has been installed to see if the cover cross section is performing as expected at Cell #2. There is a document in progress that describes this and it should be released within one month. Previously, the Tribe expressed concern that the assumptions of the pyrite oxidation model and the acid neutralization potential (ANP) that is implicitly assumed in the ICTM are not consistent. EFR said that there is no reason for the ANP to be consistent with the pyrite oxidation model because the ICTM calculations focused on the unsaturated zone and the pyrite model focuses on the saturated zone

Recommendations

Although not designed for examination of contaminant plume development at the site, the ICTM provides a framework for additional sensitivity analyses that could address many of the concerns raised by both the Utah Department of Environmental Quality and the UMUT EDP. This could be accomplished by using the model to investigate other potential flow paths that would lead to more rapid down gradient transport of contaminants, a wider range of values for the acid neutralizing potential and sorption capacity in the vadose zone and saturated zone, representations of more conservative puncture models for the tailing cells liner as well as the practicality of using other tracers as early indicators of leakage from the tailing cells.

Retardation of uranium and other contaminants of concern along potential flow paths from a leaking tailings cell to the perched aquifer depends on aqueous speciation as well as mineralogical content along the flow path. The information obtained in the pyrite and iron oxide distribution studies described above should be examined to see if a model for distribution of iron oxides can be constructed. Although the contractor to the Site owner assumed a certain amount of iron oxide in their contaminant transport model, it was unclear if the concentration was varied over a wide enough range in a sensitivity analysis. Examination of the input files from the simulations would answer this question. In addition, it was argued that the presence of bicarbonate complexes of uranium will drastically reduce the amount of potential sorption onto clay and iron oxide surfaces. However, it has been demonstrated that these complexes can sorb by specific sorption mechanisms such as inner-sphere complexes (Park et al., 1995). Additional reactive transport simulations could be run which include additional sorbing species and different concentrations of iron oxide sorption and clay iron exchange sites.

Additional confidence in the models of potential contaminant transport from the tailing cells to the accessible environment could be obtained by using 2-D or 3-D transport models. Other types of parametric sensitivity analyses could be carried out. For example, the retardation factors consistent with a fractured dominated rock could be calculated and compared to those with the current porous media assumption. These calculations would use a range of HFO concentrations and additional sorbing uranyl species to calculate effective K_ds and alternate models for retardation factors with variable assumptions about fracture surface area. The

current modeling efforts should be continued to address the worst-case scenarios that are proposed by the Tribe.

3. ***Could a multicontaminant plume persist in the environment for many generations, constituting an incalculable risk?***

If the model assumptions are correct and all processes are correctly represented , then the ICTM calculations suggest that it is unlikely that such a plume will reach potentially exposed populations within 240 years. However, the long term fate of such a plume as not been established by the ICTM mode. The controversy around these results is similar to that present for other contaminated surrounding DOE facilities or potentially contaminated sites around proposed uranium mine sites. One approach to address the risk that might be present after cleanup of such sites or to minimize future risks at proposed mine sites is through Monitored Natural Attenuation (MNA). As originally defined by the USEPA (1999), MNA is:

"...[t]he reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods. The 'natural attenuation processes' that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants." (EPA 1999, page 3)

For inorganic constituents present at White Mesa, the most potentially important processes include dispersion and immobilization (reversible and irreversible sorption, coprecipitation, and precipitation.) Determining the existence and demonstrating the irreversibility of these mechanisms are key components of a sufficiently protective monitored natural attenuation remedy. The USEPA has published guidelines for the use of Monitored Natural Attenuation (MNA) for a variety of contaminated sites (US EPA OSWER Directive 9200.4-17, 1997; USEPA, 2015).

Primary attenuation pathways for uranium are dilution and sorption, typically by iron oxyhydroxides, however, other mineral phases can adsorb uranium. Uranium-contaminated soils from surficial aquifers at two UMTRA sites (Riverton, Wyoming and Monticello, Utah) were subjected to a series of selective extractions to determine the host mineral for uranium. In the Riverton soils, about 14% of the uranium was associated with the poorly crystalline Mn-Fe oxyhyroxides. The general order of U association was: refractory minerals > carbonates > poorly crystalline Mn-Fe oxyhydroxides >> crystalline Mn-Fe oxyhydroxides >> readily exchangeable surface sites. In contrast, at Monticello, the bulk of the uranium was associated

with crystalline Mn-Fe-oxyhyroxides (15-60%) and carbonates (20-45%). (Bryan and Siegel, 1997)

Jove-Colon et al (2001) attempt to draw some general conclusion about limits to groundwater migration of uranium in various hydrolithologies by summarizing the size of plumes at uranium mill tailing sites . A variety of sources are considered including natural analogue, in situ uranium leaching sites, and UMTRA Title I and Title II milling sites. The authors conclude that most plumes (defined at the 20- 40 ppb concentration isopleth) are less than 2 km in extent. Although the estimates of plume extent are very inexact and the time periods are either very short or very long and may not be relevant to MNA, the report contains information from and references to over 30 case histories of uranium migration.

Recommendation

A MNA evaluation similar to that required by the EPA directives should be considered for scenarios relevant to White Mesa. The MNA approach is a tiered process as follows (USEPA, 2015, page 26):

- Phase I: Demonstration that the groundwater plume is *not expanding*.
- Phase II: Determination that the *mechanism and rate* of the attenuation process are sufficient.
- Phase III: Determination that the *capacity* of the aquifer is sufficient to attenuate the mass of contaminant within the plume and the *stability* of the immobilized contaminant is sufficient to resist re-mobilization.
- Phase IV: Design of a *performance monitoring program* based on an understanding of the mechanism of the attenuation process, and establishment of contingency remedies tailored to site-specific characteristics. This phase in effect reflects recommendations in the 1999 MNA guidance, but consolidated into a single, additional phase.

The heart of the MNA approach is the monitoring program. The goals of the programs are to (USEPA, 2015, page 15):

- Demonstrate that natural attenuation is occurring according to expectations;
- Detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological or other changes) that may reduce the efficacy of any of the natural attenuation processes [footnote in original deleted];
- Identify any potentially toxic and/or mobile transformation products;
- Verify that the plume(s) is not expanding (either downgradient, laterally or vertically);
- Verify no unacceptable impact to downgradient receptors;

- Detect new releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy;
- Demonstrate the efficacy of institutional controls that were put in place to protect potential receptors; and
- Verify attainment of remediation objectives.

Although there is not a one-to-one correspondence between the MNA approach for DOE contaminated sites and potential contamination of White Mesa, many of the elements of the two sites are similar and the use of an accepted approach to guaranteeing the safety of potentially exposed populations might provide assurance to the Tribe (see also Davis et al, 2011).

4. ***What is the importance of airborne releases of radionuclides and deposition on plants to overall radiological dose to the population in the area?***

There are 2 areas of concern with respect to air quality: 1) transport of dust particles produced from the tailings transported to the site and as they are stored on pads at the site and 2) radon release from tailing cells and transport to surrounding populations. The material that is shipped to the mill for reprocessing comes in a variety of forms including uranium mill tailings, residues from treatment plants, and other radioactive waste forms. Of particular concern is the dust and fine particulates associated with the uranium mill tailings. These are shipped in large trucks along the highway and until three years ago the ore was not covered. This material will sit on pads at the facility until sufficient amount is received to justify operating the mill. There is evidence collected by the USGS and the Tribe suggesting that uranium-containing dust is blown from the mill to the surrounding area. Relatively high concentrations of uranium and vanadium have been measured in soils, or water, and plants that lie along dominant wind paths and in the ephemeral stream drainage basins that are connected to entrance Springs and several monitoring wells (Naftz et al, 2011).

Analysis: Studies of uranium concentrations in sediments and plants

The USGS study (Nafatz et al. 2011) suggests that elevated uranium concentrations in Entrance Springs may be the result of contamination by uranium/vanadium rich dust blown from either the Mill pads or trucks delivering ore to the facility. This possibility is based on similarities in the δ_{34}Sulfate values in water samples from the wildlife ponds and the tailings cells and the fact that Entrance Spring has high U concentrations and a relatively low $^{234}U/^{238}U$ Activity Ratio, reflecting mixing with aerosols from the ore pads. In addition, oxygen and hydrogen isotopes of water samples collected from Entrance Spring lie on an evaporative enrichment line relative to water from Recapture Reservoir, which is the source of water for Mill operations.

Geochemical analyses of sediments in the area also support this hypothesis. Concentrations of uranium and 41 other chemical constituents were measured in stream sediments collected by the USGS from 28 sites in the ephemeral-stream channels draining the White Mesa mill.

Elevated-U concentration (greater than estimated background concentrations of 1.8 to 3.6 ppm) were found in 7 sediment samples in three ephemeral drainages east of the eastern mill boundary. In general, this area is downwind from the uncovered ore materials that are stockpiled at the mill and are in the same general area as Entrance Spring. A sample (WM2-S21) located approximately 1.2 km south of the mill site in an ephemeral drainage originating within the mill boundaries, contained the highest U concentration (greater than 16 ppm) measured in any of the sediment samples. Uranium concentrations at 20 other sites were lower than the estimated background concentration.

Principal component analysis (PCA) was applied to the full data set of 41 analytes measured in the 28 sediment sites. Three factors accounted for 76% of the variance in data set. One of the factors characterized by relatively higher concentrations of Mo, As, S, Se, U, W, and Sb, was proposed to represent contributions of U-ore material contained within the White Mesa mill site. The locations of the six samples with high ore-migration scores are located primarily in the ephemeral drainages directly east of the mill site, i.e. the same areas with elevated-U concentrations in the ephemeral drainage watersheds. Tissue samples were collected from big sagebrush in areas surrounding the White Mesa Mill site; elevated concentrations of U and V were found in samples collected north-northeast, east, and south of the mill site, consistent with offsite eolian transport in predominant wind directions. Appendix 5A provides more details of the results of the forensic studies.

There were some disagreement between the Utah DEQ and the UMUT EPD about environmental air quality monitoring at the facility prior to relicensing. These include :

- High volume PM10 samples without speciation for radionuclides leading to underestimation of radiological risk,
- Location of a "background" monitoring station to west of the Mesa that was not really background location and then basing the reporting on flawed "background levels",
- Different operating procedures: the Utah DEQ monitors 24/7 and then pulls the filter for analysis whereas the Tribe monitors for shorter periods. The Tribe does this because they feel that the monitors are delicate and if loaded up too high with dust they will bog down and not collect dust correctly (i.e. the motors burn out). Even though the Utah DEQ QA procedure mandates replacement, the measurements are flawed according the Tribe.

The Tribe feels that their position is supported by the results of the 2011 USGS study. That study found a pattern of radionuclide migration to NE as indicated by elevated U and V concentrations, however, the EFR air monitoring program didn't pick up this pattern (next to ore pad, next to drying ovens) This is a likely source so the Tribe has doubts about the EFR monitoring system. The Mill stockpiles multiple piles from different ores on the pad and according to the Tribe they don't control the dust adequately. EFR has said the required opacity measurements were enough to protect the environment but anecdotally, Tribal members see plumes of dust from the ore pad. Finally, the existing Minor source *Air Quality Permit* doesn't include all members of the radiological decay chain so the Tribe thinks the actual

radiological risk is underestimated. This can only be addressed by modifying the definition of the *Source* in the Permit.

EFR argues that the contamination is likely from historic operations not associated with current Mill activity. Specifically, some dust probably comes from the Plateau Buying Station which was a uranium ore buying station in the late 1970s. This was located north of the Mill site; by current standards, this was not a well-regulated operation and could have led to dust pollution. The high uranium in the sediments to the south of the site might be from ore from the Cottonwood Mine that was transported along the road by the facility in the 1950 before the county road was rerouted to its current location.
With respect to current sampling procedures, EFR says that their high volume dust monitors are running at least 75% of the time each quarter according to regulations. In fact, they run 90% of the time as shown by their maintenance records. The maximum downtime at a monitoring site would be six days according to their SOP.

Analysis: Radon Releases from Tailings Cells Cells #2 and #3

There are several issues related to radon releases from the tailings cells:
1) Reports of radon emissions greater that 20 pCi/m3 led to attempts to accelerate closure and drying of Cell #2 by pumping slimes to Cell#3. This has resulted in higher releases of radon from Cell#3 which exceed the 20 pCi release standard. EFR reports that averaged radon releases from Cell#2 are below the Standard but UMUT EPD and Grand Canyon Trust challenge the way the averages were calculated (mixing old and new data).
2) Radon emissions from Cells #4a,b are also in dispute. EFR has argued that the liquid barrier covering the tailings reduces radon releases to essentially zero, therefore there is no need to monitor Rn flux. UMUT EPD argues that because the cell contains significant amounts of radium, emissions are much higher according to their conservative calculations. Additionally, UMUT EPD argues that routine radium measurements are easy to make (based on common In Situ Recovery industry operations) , and should be done in the liquid.
3) The Tribe, Energy fuels and the USEPA are in discussions about regulations concerning radon emissions. The Tribe has been concerned that potential changes to NESHAP will affect monitoring requirements for radon emissions from the tailing cells. In 2008, the EPA examined potential amendments to the rule at the request of several NGOs. At the heart of the dispute is whether solutions in tailing cells should be monitored routinely for radon emission.

The Tribe's model for radon emissions from evaporation ponds at the Mill indicates that emissions are in excess of regulatory limits. Energy Fuels measurements, however, do not show any exceedances at the perimeters of the tailings, with the exception of one cell (Cell #3) that exceeded the Standard and currently is monitored on a monthly basis. A cover has been added to reduce radon emissions, which are likely due to dewatering of the solids; EFR expects that these exceedances will be only temporary.

In Energy Fuels Resource's view, the Tribe inappropriately applied the radon model of Cohen and Associates (Cohen, 2010). This model calculates radon emissions as a function of the concentration of radium-226 and wave action for a liquid evaporation pond. The Tribe used published gross alpha measurements instead of the radium measurements and wind action data from a local (off-site) meteorology station. These two assumptions led to overestimates of the radon emission for the following two reasons: 1) gross alpha radioactivity is not a good proxy for radium activity in the acidic solutions in the tailing cells; most of the activity is due to thorium-230, and 2) the model is not appropriate for the high viscosity solutions in the tailing cell. In addition, EFR argues that the wind action predicted by the meteorology station is not a good indicator for local conditions which tend to be more quiet than those at the station. The wind velocity at the tailings cells is much lower than that measured at the wind monitoring station which is a tower 1 meter tall. In addition, that location is 15 m above the tailing cell surface. Even when there is a breeze at that elevation, the surface of the tailing cells is like a "mirror".

Recommendations:

Many aspects of this topic are beyond the scope of the current contract and the core competencies of LJS Consulting, Inc., therefore, only a few recommendations can be made. As discussed above (Appendix 5A, Review of Geochemical Forensic Studies of Ground Waters), it has been proposed that additional isotopic studies using radium isotope s be initiated in collaboration with Duke University. These can include analysis of dust samples from the air quality monitoring stations to determine the source of the radiological components of the dust. The Tribe's concerns about windborne contamination could be addressed by better monitoring of radon sources and wind velocity by:

- placing a Rn monitor at the cells and not at the Site perimeter
- measuring Ra in the tailings so that Cohen's equation can be verified or applied to the tailings solution.
- measuring wind velocity at the tailings pond to obtain more relevant wind velocities,
- doing an *activity exposure* assessment to see if dust is a problem when people are on the reservation land, and
- doing exposure assessment that includes all pathways that could be important.

A potential hazard might be indicated by odors detected by residents.. When the wind shifts in the evening, area residents say they can smell the acid tailings. EFR acknowledged this but did not think it was health hazard; people were smelling organics from mill. These emissions needs to be evaluated for potential health effects.

Establishing Trust Among Stakeholders: Application of the DOE ITRD Process

The White Mesa Mill site is characterized by complex site hydrogeology, poorly documented pre-mill activities, a complex nature of the materials managed by the Site, lack of trust among some of the stakeholders, cultural perspectives that impact the priorities of the Stakeholders

and limited funding. As evidenced by the numerous Requests for Agency Actions (RAA) filed by the UMUT EDP, it is clear that there is no simple way to resolve the areas of uncertainty and satisfy the concerns of the Tribe with respect the long-term risk posed by the Mill facility. There is a large number of complex technical issues that are important and a team of experts would be required to provide a comprehensive evaluation of these issues. This situation is similar to that found at many of the Legacy Sites within the DOE Complex. The Innovative Treatment and Remediation Demonstration (ITRD) Program was initiated in 1993 by the DOE in cooperation with the Environmental Protection Agency's Technology Innovation Office to accelerate the implementation of innovative remediation technologies at these sites. The ITRD Program was based on a public-private technology demonstration concept that improved communications and teamwork among key participants. Government, industry, and regulatory agencies were directly involved in assessing, implementing, and evaluating technologies.

The first step in the process is to establish a Technical Advisory Group (TAG) with participants from site-specific government, industry, regulatory, and stakeholder groups, as well as technical experts (in site specific conditions as well as potential remediation technologies). This partnership allows a focused effort to define the problem, to identify paths to reach restoration solutions and to provide resources to assess innovative approaches that need further evaluation. Finding acceptable solutions that meet institutional, regulatory, public, and technical requirements requires a team approach to address the many issues and tradeoffs that arise in the search for the most optimal solution. The TAG performs this work through meetings, conference calls, and individual efforts to explore particular issues. Recommendations from the TAG are presented to DOE for implementation.

ITRD projects included sites with complex industrial soil and ground water contamination problems. Contaminants at such sites include chlorinated solvents and petroleum products; pesticides, polychlorinated biphenyls (PCBs), and dioxins; heavy metals; explosives; and radionuclides. The program was very successful during the period 1999 to 2002. During FY2000, for example, ITRD projects were carried out at several DOE facilities including the Paducah Gaseous Diffusion Plant, the Oak Ridge Y-12 Plant, the Hanford Site, the Pantex Plant, the Mound Plant, and Los Alamos National Laboratories. (Kelley et al. 2002; Siegel et al. 2003). The projects involved initial screening of 30+ technologies to remediate contaminated soils and groundwater, detailed evaluation of 12 different technologies, and planning or execution of several pilot deployments. Active source removal, passive barriers, bioremediation and monitored natural attenuation were evaluated for remediation of chlorinated solvents (dissolved and DNAPL), explosives and radionuclides.

Summary: Activities to Reduce Uncertainty and Risk- a graded approach

Due to the limited resources allocated for this project, only a preliminary understanding of all the complex issues has been obtained by this contractor. The focus of this work has been to obtain an overall understanding of the relationships among important technical and regulatory

issues and to make some preliminary recommendations on how to resolve some of the disagreements among the stakeholders. The product of this current contract is not a list of 'magic bullets' to resolve these issues but rather it is to identify areas of uncertainty important to the assessment and management of the risks associated with the operation of the White Mesa Mill.

Based on reviews of documents supplied to LJS Consulting, Inc and discussions with staff from the UMUT EDP, the UDEQ and Energy Fuels, several areas of technical uncertainty have been identified and classified according the level of effort that would be required to resolve them. These recommendations might change if additional reports are supplied to LJS Consulting, Inc in the future. The recommendations are classified as:

- Level A: Issues that might be addressed with review of additional existing documents,
- Level B: Issues that might be addressed with additional modeling or new data analysis,
- Level C: Issues that might be addressed with collection of new data and analysis of these data,
- Level D: Questions that are unlikely to be answered without significant expenditure of resources that may be beyond the scope of the stakeholders or that may never be answered due to irreducible uncertainties.

Level A: Issues that might be addressed with additional review of existing documents,

- Evaluation of application of Cohen and Associates model for radon emission from liquid tailings cells.
- Review of the PHREEQC calculations done in the ICTM to evaluate the adequacy of the sensitivity analyses, conservatisms of model assumptions and whether sufficient data has been obtained to support a representative model of the site.
- Detailed review of Geo-Logic model for alternative hypothesis for natural variability. This would include independent modeling using PHREEQC to determine if pyrite dissolution can be occurring and caused the pH changes when using reasonable ANP estimates.

Level B: Issues that might be addressed with additional modeling or new data analysis,

- Additional modeling - look at alternative conceptual models for the Integrated Contaminant Transport Model:
    - evaluate potential role of transport in fracture by parametric sensitivity analysis,
    - conduct sensitivity analysis with reactive transport model,
    - use additional geochemical data for both solutes and solids,
    - run simulations for more than 200 yr.

Level C: Issues that might be addressed with collection of new data and analysis of this data,

- Completing the analysis of potential role of pyrite oxidation as a cause of pH decreases and metal concentration increases in monitoring well by measuring additional redox couples in groundwater and more fully characterizing pyrite and iron oxide occurrences in the unsaturated zone.

- Additional modeling with HP-1 using multiple alternative interpretations of data obtained through geostatistical analysis of hydrological and mineral occurrence data.
- Addressing concerns about windborne contamination by better monitoring of radon sources and wind velocity.
- Determining the potential for using a Monitored Natural Attenuation approach at the site.
- Proceeding with the installation of 3 new wells as suggested by EFR to be placed in the perched zone to characterize groundwater flow and direction in the area southeast of MW-17 , between MW-17 and MW-22.
- Doing an activity exposure assessment to see if dust is a radiological exposure problem when people are on the reservation land.
- Doing an exposure assessment that includes all pathways that could be important to human health. Including the estimated exposures in a complete health risk assessment including doses-response relationships for contaminants of concern.
- Addressing UMUT EDP concerns about Mill work practices:
    - water sampling - doing a verification exercise
    - air monitor sampling - comparing the different SOWs used to industry standards
- Consider additional tracers for setting Ground Water Compliance Limits
    - doing a scoping analysis of other potential tracers to evaluate their usefulness relative to chloride.
    - Evaluate using additional forensic isotopes and trace metals.
- Formulating a hydrological model that includes transient effects related to the draining of the wildlife ponds, effects of ongoing remediation efforts and provides information to the Tribe that addresses concerns about placement of new tailings cells close to the Site Boundary in the future.

Level D: Questions that are unlikely to be answered without expenditure of resources beyond the scope of the stakeholders or that may never be answered due to irreducible uncertainties.

- Why do we think that the old tailing cells are still sound, years after their design life?
- How do we know cells are not leaking if the leak detection systems (LDS) are not adequate?
- Prediction of the long term transport of contaminants from the tailing cells over time periods that are consistent with cultural beliefs of the Ute Tribe.

Finally, it is suggested that the Stakeholders at White Mesa consider using the method developed by DOE's Innovative Technology and Remediation Development program to establish a consensus about what additional steps are needed to be taken to evaluate potential leaks and off-site transport of radionuclides. In this effort, the Bureau of Indian Affairs might be considered a **neutral party** that can do mediation. In this analysis, the participants would focus

on human health risk, consider importance of cultural issues, and introduce new technologies when really relevant and cost effective.

LIMITATIONS STATEMENT

The opinions and recommendations presented in this report are based upon the scope of services and information obtained through the performance of the services, as agreed upon by LJS Consulting, Inc. and the party for whom this report was originally prepared. Results of any investigations, tests, or findings presented in this report apply solely to conditions existing at the time LJS Consulting, Inc' s investigative work was performed and are inherently based on and limited to the data provided to LJS Consulting, Inc by that party and the limited resources of the investigation activities as defined by the contract (labor hours and hourly rate). No representation, warranty, or guarantee, express or implied, is intended or given. LJS Consulting, Inc makes no representation as to the accuracy or completeness of any information provided by other parties not under contract to LJS Consulting, Inc. to the extent that LJS Consulting, Inc. relied upon that information. This report is expressly for the sole and exclusive use of the party for whom this report was originally prepared and for the particular purpose that it was intended. Reuse of this report, or any portion thereof, for other than its intended purpose, or if modified, or if used by third parties, shall be at the sole risk of the user.

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Figures

Tables

Appendices

APPENDIX 5B

Introduction to Use of Uranium and Radium Isotopes in Geochemical Forensic Studies

(abstracted from Bryan, C., Siegel. MD, and Heikoop, J., 2011.

Uranium and radium isotope activity ratios provide a useful tool for establishing the provenance (source) of groundwater contamination. Moreover, even in areas where elevated concentrations of these elements are naturally occurring, the activity ratios can provide information about the source lithologies and hydrologic conditions, and potentially aid in establishing a treatment strategy. As mines and tailings dumps are generally located in areas with elevated background levels of the metals being mined, accurately distinguishing metals released due to mining from natural occurrences of these metals can be difficult using only contaminant concentration values and conventional groundwater geochemistry. Large volume mining and milling residues contain about 85% of the radioactivity of the unprocessed uranium ore, primarily in the form of U radioisotopes, ^{230}Th, Ra (^{226}Ra and ^{222}Ra), Rn isotopes, and short-lived radioactive daughters further down the uranium decay chains.

Naturally occurring uranium consists dominantly of two isotopes, ^{238}U (99.3%) and ^{235}U (0.7%). These isotopes undergo radioactive decay through a series of intermediate daughters to ^{206}Pb and ^{207}Pb, respectively. Similarly, ^{232}Th decays to ^{208}Pb. Although ^{235}U and ^{238}U generally occur in nearly the same proportion in nature, a third isotope, ^{234}U, is produced as part of the ^{238}U decay chain and its concentration can vary greatly relative to the other isotopes. Moreover, there are four different isotopes of radium (^{223}Ra, ^{224}Ra, ^{226}Ra, and ^{228}Ra) that are produced in the ^{238}U, ^{235}U, and ^{232}Th decay chains, and the relative concentrations of these can vary greatly because of the differing chemistry of their parents in the decay chains and also because of their widely varying half-lives. Some radium isotopes have very short half-lives, making them useful in determining whether the parent isotopes are coming from local sources or are being released from a distance source.

Within an undisturbed sample, after several half-lives of the longest-lived intermediate daughter, a radioactive parent and its unstable daughters will reach secular equilibrium; the contribution of each nuclide to the total activity will be the same. In naturally-occurring rocks, the absolute concentrations of elements in the decay chains vary because of the variations in the half-lives, but the daughters in a given decay chain are usually close to secular equilibrium. However, in groundwater systems, there are commonly large differences in the activity levels of the parents and daughters in a decay chain. The major reason for the difference in activities is the different elemental chemistry of Ra, U and Th (for example, the much higher solubility of Ra than U, or the different redox-sensitive adsorption behavior of U and Ra).

In general, concentrations of the daughters in a decay chain can vary by orders of magnitude and isotopic ratios can cover a huge span. However, the activities of all the radionuclides in a decay chain will be the same if secular equilibrium exists; therefore, it is convenient to compare the activities of the radionuclides rather than the actual concentrations. Of specific interest in the uranium and thorium decay chains are be the ^{234}U/^{238}U activity ratio and the ^{224}Ra/^{228}Ra and ^{228}Ra/^{226}Ra activity ratios (ARs). The isotope ^{234}U ($t_{1/2}$ = 246,000 years) is produced by decay of ^{238}U via two intermediate daughters with short half-lives, ^{234}Th ($t_{1/2}$ = 24 days), and ^{234}Pa ($t_{1/2}$ = 1.2 minutes). Because of the moderately long half-life of ^{234}U, it does not reach secular equilibrium with ^{238}U for many hundreds of thousands of years. In a closed system, the ^{234}U/^{238}U AR would be less than 1.0 as ^{234}U ingrows, and would be 1.0 once secular equilibrium is reached. It would never be greater than 1.0. However, in natural surface waters, the

ratio is generally between 1 and 2; in the oceans, for instance, it is fairly consistently about 1.15. In natural groundwaters, the $^{234}U/^{238}U$ AR can be 10 or higher (Osmond and Coward, 1976).

It is clear that, although ^{234}U and ^{238}U are chemically identical and do not fractionate because of mass, there are mechanisms by which enrichment of ^{234}U in waters occurs. There are two primary causes for this enrichment, both related to the radioactive decay of the parent, ^{238}U, and of the intermediate daughters, ^{234}Th and ^{234}Pa (Osmond and Coward, 1976). First, decay of the parent and intermediate daughters damages the local crystal structure of the mineral in which ^{238}U resided (the Slizard-Chalmers effect). Because of the damage to the crystal lattice, the damaged areas are somewhat more soluble that the undamaged areas, and preferentially dissolve and release ^{234}U. Also, there is greater probability that these ^{234}U atoms have been converted to the more soluble uranyl ion due to the effects of radiation-induced ionization. Second, decay of ^{238}U can cause the displacement of the intermediate ^{234}Th daughter (which rapidly decays to ^{234}U) off crystal surfaces or out of the near-surface lattice into the adjacent water by alpha-recoil processes. The amount of excess ^{234}U relative to ^{238}U is controlled by ^{234}U decay, water/rock ratios, flow path length, and the amount of bulk rock dissolution in the aquifer. In general, the much greater mass of uranium in the rock relative to the pore water means that the $^{234}U/^{238}U$ AR in the water is much more sensitive to the fractionation processes than the ratio in the rock.

In dynamic or geochemically perturbed systems where mineral dissolution is occurring rapidly, ^{234}U and ^{238}U are released in amounts proportional to their abundance in the rock, and the $^{234}U/^{238}U$ AR in the groundwater will be close to 1.0. In stable, near-equilibrium systems, the $^{234}U/^{238}U$ AR will be higher, as the radiochemical fractionation due of alpha recoil and preferential dissolution of crystallographically damaged regions are more significant. Moreover, in reducing systems, where uranium solubilities are low, the alpha recoil effect begins to dominate $^{234}U/^{238}U$ AR values, resulting in higher values. For this reason, it is common in groundwater studies for the $^{234}U/^{238}U$ AR to inversely correlate with uranium concentration and to provide an indication of redox condition. In purely oxic groundwater systems, $^{234}U/^{238}U$ AR values can be used as a mixing indicator.

Values of $^{234}U/^{238}U$ AR have been used in several studies to provide insights into hydrologic conditions in groundwater aquifers, in addition to the relatively common use of uranium series disequilibrium methods to age-date groundwaters. Cowart and Osmond (1977) showed that uranium in groundwater downdip of a uranium roll-front deposit (that is, in the reducing zone) was not only lower in uranium, but also was relatively enriched in ^{234}U. This was because precipitation of uranium at the roll-front is non-selective, but at the reducing barrier, the accumulated uranium is preferentially releasing ^{234}U into the water. Coward and Osmond proposed that while elevated $^{234}U/^{238}U$ ARs do not necessarily indicate an upstream accumulation of uranium, when coupled with an abrupt decrease in uranium concentration, the two features might be a useful diagnostic for identifying uranium deposits.

Otton et al. (2010) used $^{234}U/^{238}U$ AR values to quantitatively apportion uranium in groundwater to different sources in Fry Canyon, Utah. Fry Canyon is the site of an old copper/uranium mine, and uranium tailings and associated ponds represent point sources for uranium contamination in local soil and groundwater. They showed that the uranium tailings are undergoing active oxidation and mineral dissolution, and uranium being released from the site has $^{234}U/^{238}U$ AR values near 1.0; four wells at the site had groundwater AR values averaging 0.939. Groundwater AR values from seven upstream waters averaged 1.235. Elevated uranium concentrations in downstream monitoring wells, could, on the basis of their AR values (~0.98 to 1.01) and on isotope mass balance constraints, be sourced dominantly (78-87%) to site-derived uranium.

Similarly, Zeilinski et al. (2008) evaluated surface waters in an area west of Denver, Colorado with both undisturbed uranium-rich bedrock and non-economic occurrences of uranium minerals, and several uranium deposits that had previously been mined. They found that the $^{234}U/^{238}U$ activity ratios of acid mine drainage (0.95 to 1.0) were distinct from those of local surface waters, which were greater than 1.05. Hence, even in an area with naturally elevated uranium, mine wastes produced a distinctive isotopic signature that could be used for source attribution.

In a third study, Johnson et al. (2009) evaluated groundwater samples with elevated uranium near an open municipal dump Tuba City, Arizona. It was suspected that the uranium was derived from an upstream uranium mill tailings site, from which a groundwater uranium plume extends. However, Johnson et al. were able to show that the elevated values were not derived from the upstream uranium mill tailings site. Groundwater samples from the plume coming from the tailing site, had $^{234}U/^{238}U$ AR values of about 1.0, as expected for a young source. However, the groundwaters with elevated uranium near the dump had $^{234}U/^{238}U$ AR values of more than 1.5, indicating that the uranium could not have come from the tailings contaminant plume. Johnson et al. concluded that the elevated uranium by the dump was derived from cycling of uranium derived from weathering of reworked Chinle sediments in the soil zone.

Radium isotopes

Radium isotopes are produced by radioactive decay of uranium and thorium parents (Figure 1). Concentration of Ra is consistently controlled by its geochemical properties, primarily the properties that control sorption, desorption, and ion exchange. Factors related to geology and climate that affect the acidity, redox potential, degree of mineralization, and composition of ground waters, as well as their potential residence time, can control sorption and thereby the occurrence pattern of the isotopes of Ra. Radium in groundwater can be derived from multiple sources including (1) Ra in-growth via decay of the dissolved Th parents in the solution; (2) dissolution from the aquifer minerals; (3) alpha-recoil from the parent nucleus in the aquifer rocks and on the clay and oxide surface coatings; (4) adsorption/desorption exchange with Ra adsorbed on the surface coating, clays, and oxides; and (5) coprecipitation with and/or dissolution of secondary minerals (e.g., barite) (Vengosh et al, 2009). However, direct ingrowth from thorium is generally negligible in fresh near-neutral water due to the much lower solubility of thorium than radium, and dissolution is possible but ultimately is not favored in fresh water systems because it is too slow relative to the half-lives of short-lived radium isotopes. Radium isotopes are continuously released to groundwater contained in pore space of porous media or within fractures in bedrock by alpha-recoil mechanisms from mineral surfaces or surface coatings (Fleischer, 1980; Tricca et al., 2001); in extreme cases, this can the primary source of radium in groundwater, and other sources of radium to water are negligible (Krishnaswami et al. 1982). Figure 1 describes some the pathways by which isotopes of radium, thorium and uranium can be partitioned among water, surface and bulk rock reservoirs.

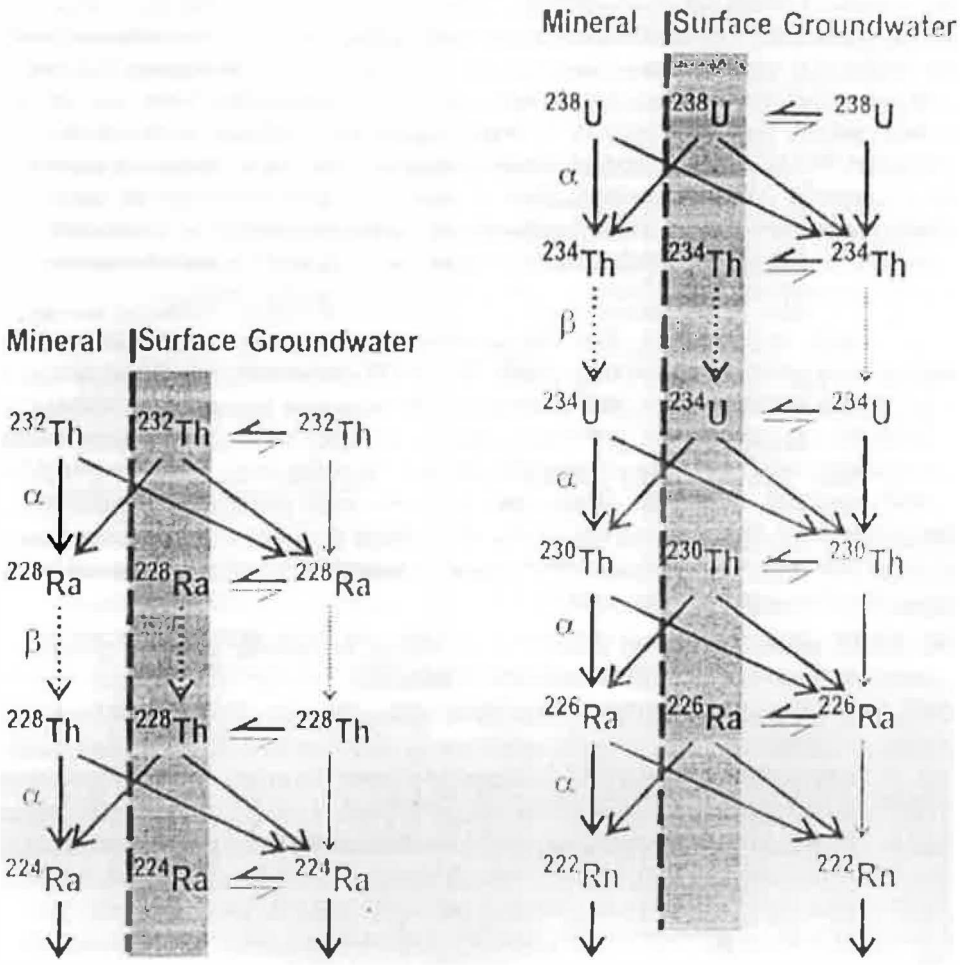

Figure 1. Systematics of radionuclide decay, sorption and releases along the ^{232}Th (left) and ^{238}U (right) decay series. Major fluxes are indicated by bold arrows, minor fluxes by fainter arrows. Nuclides are supplied to the water and surface coatings by alpha recoil of parents in the mineral; radionuclides in the water and surface exchange by sorption/desorption. The mobile pool of radionuclides increases along the decay chain. Long-lived radionuclides that are mobile such as ^{234}U may not reach steady state in cases where advection is important (from Porcelli and Swarzenski, 2003).

^{228}Ra/^{226}Ra ratios

The ^{228}Ra/^{226}Ra ARs can provide some insight into the source of radium as well as the geochemical processes that control its mobility. The ^{228}Ra/^{226}Ra AR is often considered to be equal to the average Th/U activity ratio in the aquifer rocks (Dickson 1990); for igneous rocks, this would be in the range of 1 to 1.4, corresponding to a Th/U weight ratio of 3–4, the ratio of these elements in the earth's crust. However, other rock types commonly vary from this range—for instance, carbonates are preferentially enriched in uranium relative to thorium, and clastic rocks may be enriched in thorium, in trace minerals resistant to chemical and physical weathering, relative to more readily leached uranium. Post-depositional enrichment or depletion of these elements in the aquifer rocks could result in variations in this ratio. Moreover, other processes can result in differences between the Ra isotopic composition of the rocks and the water. Dissolution of Ra-containing minerals would result in low ratios of the short-

lived to long-lived Ra isotopes (e.g., low $^{228}Ra/^{226}Ra$ ARs) relative to the host aquifer rocks, given the slow dissolution rate and relatively faster decay of the short-lived Ra isotopes. In contrast, combination of the recoil process and decay of the dissolved radium isotopes and their rapid adsorption would increase the relative abundances of the short-lived Ra isotopes (i.e. higher $^{228}Ra/^{226}Ra$ ARs). ^{226}Ra is enriched relative to ^{228}Ra in waters from a variety of rock types, but especially in the carbonate-rock-type aquifer systems; this is likely due to the enrichment of U (relative to Th) in carbonate minerals. ^{238}U is the parent of ^{226}Ra and ^{232}Th is the parent of ^{228}Ra. In samples from Paleozoic carbonates in the midcontinental USA, $^{228}Ra/^{226}Ra$ activity ratios ranged from 0.06 to 1.48 in fluids and were similar to ratios in the aquifer rocks (0.21-1.53) (Sturchio et al. 2001). Enrichment of ^{226}Ra relative to ^{228}Ra is also common in water samples from clastic sedimentary rocks where post-depositional enrichment of U relative to Th was likely. The high solubility of ^{238}U relative to ^{232}Th is the cause for its widespread distribution, redistribution, and enrichment relative to background levels in numerous sedimentary environments.

Vengosh et al. (2009) notes that Ra activity in groundwater is controlled by a balance between the recoil process and adsorption on clay minerals and oxides. In studies of aquifers in the Middle East, the range of $^{228}Ra/^{226}Ra$ activity ratios (0.7-3) in groundwater from a sandstone aquifer, and the high $^{224}Ra/^{228}Ra$ and $^{223}Ra/^{226}Ra$ values suggest that the significant variation of Ra in the different aquifers is due to adsorption. Vengosh et al. also suggest that a high $^{228}Ra/^{226}Ra$ ratio in groundwater could be derived from either local source rocks with a higher Th/U ratio or differentiation in the rate of decay of the parent ^{232}Th and ^{230}Th nuclides on old surface coatings (see Figure 1).

$^{224}Ra/^{228}Ra$ activity ratios:

Differences in ^{224}Ra occurrence and isotope ratios depend upon geology of the principal aquifer and effects of water chemistry and recoil of ^{224}Ra (Figure 1). The activity ratio of ^{224}Ra to ^{228}Ra is generally highest (median, 3.25) in the detrital sediments of the western United States (lower Tertiary/Cretaceous sandstones and Quaternary alluvium. Ra is poorly soluble in these oxidizing and alkaline aquifer systems but the concentrations of ^{224}Ra are somewhat enhanced in solution relative to those of ^{228}Ra. This can be explained by alpha recoil of ^{224}Ra from the Th-rich (^{228}Ra-bearing) detrital sands in the western United States. The process is analogous to "recoil enrichment" for the isotope ^{234}U relative to the parent isotope ^{238}U (Osmond and Cowart, 1976). ^{224}Ra might be most enriched by the physical recoil mechanism relative to ^{228}Ra in waters where Ra is sparingly soluble (oxic and moderately to strongly alkaline waters, as in the western United States), whereas relative ^{224}Ra enrichment is least where Ra is soluble.

The concentration of ^{224}Ra has regulatory and public health implications. ^{224}Ra and its decay products can contribute substantially to gross alpha-particle activity of water. The effectiveness of the use of gross alpha-particle activity both as a standard in itself (15 pCi/L) and as a compliance-monitoring "screen" for combined Ra has been shown to depend on the holding time between sample collection and analysis because of the presence of ^{224}Ra (Parsa, 1998; Szabo et al., 2005). The USEPA recommends that gross alpha-particle activity be determined within 48 to 72 hours in order to account for the presence of the short-lived alpha-particle-emitting isotopes such as ^{224}Ra in regions where ^{228}Ra is known to be present (USEPA, 2000b).

B. EXPERIMENTAL METHOD

The majority of the activity of radium in groundwaters is ^{226}Ra and ^{228}Ra, and these can be measured using readily available and relatively inexpensive techniques. In order to measure the activities of radium isotopes in the samples, it is necessary to separate and concentrate the radium from the groundwater samples. This is carried out by filtering a relatively large volume of well-water (20-40 liters) through columns filled with acrylic fibers coated with manganese oxide (MnO_2). Radium is strongly sorbed onto the manganese oxide, and is quantitatively extracted from the water. Following extraction, the MnO_2-coated fibers were removed from the columns, squeezed by hand to extract most of the water, and then placed in sealed glass tubes to "incubate." Incubation allows the ^{226}Ra in the samples to reach secular equilibrium with its daughter, ^{222}Rn (t1/2 = 3.8 days). Following an incubation period of 3 weeks, the sample is attached to a RAD 7™ radon monitor, and the gas contained in the tube is cycled repeatedly through the RAD 7. The activity of ^{222}Rn is measured and quantified by comparison with standards prepared in a similar fashion, and is used to indirectly determine the activity ^{226}Ra. Note that the RAD 7 can be obtained for less than $10K; this analytical procedure is easily within the reach of most small businesses.

Once ^{226}Ra has been determined, the fiber samples are re-analyzed to measure ^{228}Ra, which is determined indirectly, by measuring the gamma activity of its daughter ^{228}Ac (t1/2 = 6.5 hours). The MnO_2 fibers are removed from the incubation tube, placed in a steel can and oven-dried overnight. Then, the top is placed on the can and it is crushed in a laboratory press. The flattened sample is then counted using a gamma spectrometer to determine the activity of ^{228}Ac (338 and 911 KeV peaks were used); once again the efficiency of the counting process was determined by comparison with ^{228}Ra standards made in exactly the same fashion as the samples. Again, gamma spectrometry is routinely available at reasonable cost from many analytical labs.

Although radioisotopes are useful in establishing provenance of contaminants in groundwater, the data must be combined with standard chemical analyses in order to provide the greatest understanding of the system being evaluated. For each sample collected in this study, field measurements of temperature, pH, total dissolved solids, and dissolved oxygen content should be collected, using hand-held meters. Water samples should be collected and sent to an analytical laboratory (for cation and anion analysis and for trace element analysis by ICP-MS.

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APPENDIX E

TRIP REPORT

MEETINGS WITH STAFF FROM UTE MOUNTAIN UTE TRIBE ENVIRONMENTAL PROGRAMS DEPARTMENT

NOVEMBER 30, 2016, TOWOAC, CO

AND

SITE VISIT WHITE MESA URANIUM MILL AND MEETINGS WITH STAFF OF ENERGY FUELS RESOURCES (USA) INC.

DECEMBER 1, 2016, WHITE MESA, UTAH

SUMMARY

1. Purpose and Relevance of the Infiltration and Contaminant Transport Model (ICTM)

- Model was used in support of cover design and is not expected to predict site wide contamination.
- The discussions with the State have moved beyond discussions of the model because EFR has started a real test in Cell #2, which is in the first phase of reclamation.
- Review of Final ICTM and Reclamation Plan would be useful to see how questions raised in this contract have been resolved.
- Run the ICTM for full 1000 yrs; a useful tool for sensitivity analysis, which should be done with input from the Tribe (as well as the State).

2.Air Quality Issues: Dust with Elevated Uranium and Vanadium, Radon and Odors

- EFR argues that the contamination is likely from historic operations not associated with current Mill activity.
- The Tribe has expressed concerns that current air monitoring procedures for dust and radon are not sufficiently protective.
- Energy Fuels Resources (EFR) says that their high volume dust monitors run 90% of the time as shown by their maintenance records.
- The Company argues that the wind velocity used by UMUT EPD to calculate Rn emanations from evaporation ponds was unrealistically too high.
- A potential hazard might be indicated by odors detected by residents; dust plumes and plumes coming from the facility are observed and reported anecdotally.
- EFR acknowledged this but did not think it was health hazard; people were smelling organics from mill. These emissions needs to be evaluated for potential health effects.

3. Cell #1 Failure and Future of Legacy Cells

- The Tribe asserts that the Legacy Cells such as Cell #1 are beyond their design life (30 yrs),that observed leaks demonstrate that that they leaking routinely, and must be replaced.
- The Company feels that Cell#1 worked as designed; leak detection system indicated that there was leak at a certain level, rather than search for leak, they replaced a huge section of the liner with new materials.
- The Site Reclamation plan requires that Cell #1 be dug up and material placed in a newer cell for final closure at some time in the futurewith a 1000 year cover, no active maintenance and supported by a DOE Legacy Site Perpetual Care Fund.

4. Natural Variability, Pyrite Oxidation, pH Decreases and GWCLs

- The Tribe said that the GWCL (Ground Water Compliance Level) flow chart used by the Site and the State to set Compliance Levels for metals at the monitoring wells is not same as the EPA procedure upon which it is based. (it doesn't force a outcome other

than raising the GWCL.) It would be useful to review the Ground Water Discharge Permit to see how Corrective Action is triggered.

- EFR feels that two accepted lines of evidence are sufficient to justify raising the GWCL: the Utah isotope study that says there is no leakage from cells and the pyrite oxidation 'natural variability' hypothesis.
- The State has accepted this as a "reasonable" idea. The main observations and mechanisms that support this are:
    - EFR argues that sufficient oxygen to oxidize pyrite in saturated zone waters comes from stressing the wells.
    - the decreases in pH are observed site-wide; effects in MW 18 (which is upgradient) and MW-3 (down-gradient) are the most pronounced.
    - the chloride plume is not seen upgradient where the pH is also decreasing.
- Potential follow-up work:
    - Detailed review of Geo-Logic model for alternative hypothesis for natural variability. This would include independent modeling using PHREEQC to determine if pyrite dissolution can be occurring and caused the pH changes when using reasonable ANP estimates.
    - Work with Bureau hydrologist to evaluate alternative travel time estimates.

5. Cultural Issues

An underlying issue appears to be that the Tribe does not feel it is getting enough respect from the different agencies including the State and the EPA. .

SUMMARY OF MAIN TOPICS DISCUSSED DURING SITE VISIT IN NOVEMBER-DECEMBER 2016

1. Purpose and Relevance of the Infiltration and Contaminant Transport Model (ICTM)

The purpose and relevance of the ICTM for long term performance was clarified. This model was used in support of cover design and is not expected to predict site wide contamination. The 200 year modeling duration was chosen to be consistent with the Atomic Energy Act Appendix A for tailings which require 200 year minimum life but a 1000 year design life. The discussions with the State have moved beyond discussions of the model because EFR has started a real test in Cell #2, which is in the first phase of reclamation. A test section has been installed to see if the cover cross section is performing as expected at Cell #2. There is a document in progress that describes this and it should be released within one month. Previously, the Tribe expressed concern that the assumptions of the pyrite oxidation model and the acid neutralization potential (ANP) that is implicitly assumed in the ICTM are not consistent. EFR said that there is no reason for the ANP to be consistent with the pyrite oxidation model because the ICTM calculations focused on the unsaturated zone and the pyrite model focuses on the saturated zone

2.Air Quality Issues: Dust with Elevated Uranium and Vanadium, Radon and Odors

Both the Tribe and the USGS raised a concern that poor dust control on the site has led to contamination of sediments northeast and south of the Site. EFR argues that the contamination is likely from historic operations not associated with current Mill activity. Specifically, some dust probably comes from the Plateau Buying Station which was a uranium ore buying station in the late 1970s. This was located north of the Mill site; by current standards, this was not a well-regulated operation and could have led to dust pollution. The high uranium in the sediments to the south of the site might be from ore from the Cottonwood Mine that was transported along the road by the facility in the 1950 before the county road was rerouted to its current location..

The Tribe has expressed concerns that current air monitoring procedures for dust and radon are not sufficiently protective. They assert that the operating procedures for high volume dust samplers leads to equipment failure and they are considering changing to low volume samples. They have calculated that radon emissions from the evaporation ponds exceed regulatory standards.

Energy Fuels Resources (EFR) says that their high volume dust monitors are running at least 75% of the time each quarter according to regulations. In fact, they run 90% of the time as shown by their maintenance records. The maximum downtime at a monitoring site would be six days according to their SOP. In addition, The Company argues that the wind velocity used by UMUT EPD to calculate Rn emanations from evaporation ponds was unrealistically too high. The wind velocity at the tailings cells is much lower than that measured at the wind monitoring station which is a tower 1 meter tall. In addition, that location is 15 m above the tailing cell surface. Even when there is a breeze at that elevation, the surface of the tailing cells is like a "mirror".

A potential hazard might be indicated by odors detected by residents.. When the wind shifts in the evening, area residents say they can smell the acid tailings. EFR acknowledged this but did not think it was health hazard; people were smelling organics from mill. These emissions needs to be evaluated for potential health effects. The Tribe said that dust plumes and plumes coming from the facility are observed and reported anecdotally.

3. Cell #1 Failure and Future of Legacy Cells

The Tribe thinks that the leak in 2009 from Cell #1 one was catastrophic and demonstrates that the cell linings are failing. When the leak occurred, the Mill dropped the liquid levels in the cell and photographed the damage beneath the liquid level. In the Tribes view, this shows that the cell lining failed and the damage was not simply due to sunlight exposure. The Tribe asserts that the Legacy Cells are beyond their design life (30 yrs),that observed leaks demonstrate that that they leaking routinely, and must be replaced.

The Company has a different story: they feel that the leak detection system, although not as sophisticated as that in the newer cells (#4a,4b) worked as designed and indicated that there was (a small volume?) leak at a certain level. The Cell was drained below that level and they couldn't find the leak so they just replaced a huge section of the liner with new materials. They then refilled the tailings cell and there was no more leakage.

Because the waste at the site is a byproduct of uranium tailings (11e2 waste), the site will be closed permanently at some time in the future. The Site Reclamation plan requires that Cell #1 be dug up and material placed in a newer cell for final closure at some time in the future. The Site owner must clean all contaminated soils and put them in the tailing cells, including dust in the area from all around the Mill. Then the site becomes a DOE Legacy Site with a 1000 year cover, no active maintenance and is supported by a Perpetual Care Fund.

4. Natural Variability, Pyrite Oxidation, pH Decreases and GWCLs

The Tribe said that the GWCL (Ground Water Compliance Level) flow chart used by the Site and the State to set Compliance Levels for metals at the monitoring wells is not same as the EPA procedure upon which it is based. Specifically, they claim that it doesn't have an "off ramp" to force a outcome other than raising the GWCL. Examination of the chart from Intera publications confirms that this is true, however EFR claims that the flow chart does have an "off ramp" that leads to a CA (Corrective Action) It would be useful to review the Ground Water Discharge Permit to see how Corrective Action is triggered. When an OOC (Out of Compliance) condition happens, the Source Assessment Report is required and that will lead to the either CA or a change in GWCL.

EFR feels that two accepted lines of evidence are used to justify raising the GWCL: the Utah isotope study that says there is no leakage from cells and the pyrite oxidation 'natural variability' hypothesis. The Tribe has argued that insufficient pyrite oxidation could occur to lower the pH because there is not enough oxygen in the saturated aquifer. EFR argues that the oxygen in saturated zone waters comes from stressing the wells. When they purge the wells,

the cone of depression allows air to mix with the water. The wells are screened above the water line.

The State has accepted this as a "reasonable" idea. The main observations that support this are:

- the decreases in pH are observed site-wide; effects in MW 18 (which is upgradient) and MW-3 (down-gradient) are the most pronounced. The differences in the observed effect at different wells might be due to changes in water levels which leads to changes in the residence times of water along the flow path to the wells.
- the chloride plume is not seen upgradient where the pH is also decreasing.

5. Cultural Issues

An underlying issue appears to be that the Tribe does not feel it is getting enough respect from the different agencies including the State and the EPA. For example, the Tribe feels that EPA has not consulted with the Tribe sufficiently on NESHAP regulations for radon monitoring. They planned a face-to-face consultation but the person writing the rule couldn't attend in person because of health problems. This offended the Tribal Council even though that person participated in consultation by telephone. Before all of the Tribe's questions could be answered, the EPA started the public comment period and this prevents serious dialogue with the Tribe, in the view of the Tribal Council.

6. Potential Follow-up work

1. Detailed review of Geo-Logic model for alternative hypothesis for natural variability. This would include independent modeling using PHREEQC to determine if pyrite dissolution can be occurring and caused the pH changes when using reasonable ANP estimates.
2. Work with Bureau hydrologist to evaluate alternative travel time estimates.
3. Work with Bureau sociologist to evaluate problems with communication between tribe and regulatory agencies. This would involve interviews with the key participants and a trip to Salt Lake to talk to regulators.
4. Health effects: The Tribe feels that EPA did not want an exposure assessment done for this site and wants to avoid looking at human health implications of the issues that the Tribe raises. The Tribe feels that the health effects associated with the Monticello Mill are relevant to their population. The information from that site should be reviewed to see if that is a valid comparison.
5. Review of Final ICTM and Reclamation Plan to see how questions raised in this contract have been resolved.

- Run the ICTM for full 1000 yrs; why didn't they run it that long? It's a useful tool for sensitivity analysis, which should be done with input from the Tribe (as well as the State).
- Review of Reclamation Plan when it is available;

Notes from meeting with staff from Ute Mountain Ute Tribe Environmental Programs Department
Towaoc, CO; November 30, 2016

Participants:

- Malcolm Siegel, LJS Consulting, Inc.
- Scott Clow, Environmental Programs Director, UMUT EPD
- Colin Larrick, Water Quality Program Manager
- Nancy Lauer, PhD candidate Duke University
- other UMUT EPD staff

Main topics:

1. Raising the GWCL:
The Tribe said that the GWCL flow chart is not same as EPA procedure; it doesn't have an "off ramp" to force a outcome other than raise the GWCL. Examination of the chart from Intera publications conforms that this is true, however EFR had a response: i.e. Two lines of evidence are used to justify raising the GWCL: the Utah isotope study that says no leakage from cells and and the pyrite 'natural variability' hypothesis.

2a. pH changes in wells as indicator of leaking cells:
The Tribe says that pyrite study is not sufficient to explain the pH changes in their monitoring wells (the East and West wells). There are no pH changes in the Bayless well or Lyman private wells, that have been monitored quarterly for the last two years.

The Tribe feels there is inconsistency in the assumptions about pyrite model and the acid neutralization potential that is implicitly assumed in the ICTM. (I need to look at the Geo -Logic report in more detail. However they said that there is no funds available for the contractor to work with me or answer my questions.) Note: EFR said that there is no reason for the ANP to be consistent with the natural variability model because the ICTM calculations focused on the unsaturated zone and the pyrite model focuses on the saturated zone. I should compare the values for ANP in saturated and unsaturated zones.
(However, ICTM may no longer be relevant because of the test that is the carried out on the site as described in the notes.) However, I think that the I CTM could be modified to evaluate if the metals changes in pH changes at the different wells could have occurred given different assumptions about flowrates and the concentrations of sorbing sites along the flow paths.

2b. Comments on ICTM:
Tribe thought Reclamation Plan was revised in 2016 and wanted to know if this meant it was a new ICTM? The Tribe that there was a 2015 Interrogatory and that the State did not feel that the model had been finished and doesn't use the results. (See comments about the model and the reclamation plan by EFR).

3. Airborne contaminants: dust, Radon, plume (odor)

Dust plumes:

Dust and U: Colin said that there were two main wind directions. The wind direction change from day (SW) to evening (from N). They offer to show me the wind rose diagrams, (note: see discussion with EFR confirm the change in direction and that they question if this was responsible for high uranium in sediments to the South. When the wind shifts in the evening, area residents say they can smell the acid tailings. (EFR acknowledged this but did not think it was health hazard; people were smelling organics from mill. These emissions needs to be evaluated for potential health effects.) The Tribe said that plumes are observed and reported anecdotally. The Tribe has collected radionuclide data for some dust samples. This kind of data could be used in evaluation of source of dust by isotopic forensics.

Rn emissions:

The Tribe defended their radon emission model. This is a developing issue: the EPA is basing its renewal of the NESHAP (EPA 90.1) on White Mesa because this is the only mill facility in the country. They said there is no radium 226 data on site available so gross alpha activity is a good proxy for radium. The gross alpha is much higher now than in the data that was used in the evaluation by the EPA.

NESHAP:

The EPA has not consulted with the Tribe sufficiently on NESHAP. When the King memo was sent to the EPA, they include 20- 30 questions and EPA couldn't answer many of them. They planned a consultation but the person writing the rule couldn't attend in person because of health problems. This offended the Tribal Council. The person participated in consultation by telephone and told Tribal Council that cells 1, 2 and 3 would be closed, and this has not happened. Before all of the Tribes questions could be answered, the EPA started the public comment period and this prevents serious dialogue with the Tribe. The Tribe is now waiting for the OMB to comment on the proposed changes to the rule.

Cell 2 exceedances for Rn:

Due to the sampling schedule and reporting schedule for radon data it is possible that the exceedance lasted for nearly 2 years. The mill remediation was simply a 1 foot cover over the hotspots and the Tribe does not feel that this is sufficient.

4. Sampling practices

In the past ,the State had problems with the Mills' water sampling but now feels it's okay. This is because they use dedicated pumps and split sampling procedures.

Air quality sampling is still a problem due to the debate over the proper way to run the sampling motors. The Tribe is now considering using low volume sampling instead of high volume sampling. The TRibe doesn't feel that there has been sufficient sampling of vegetation; the State has resisted requests for more extensive sampling citing concerns over "denuding" the Mesa.

5. Nitrate CAP issues and nitrate source assessment report.

The State assume the nitrate was from a leaking ammonium sulfate source and the Tribe does not agree with this assumption. The Tribe is concerned that the Corrective Action Plan avoids the need to determine the source of the chloride plume which is co-located with the nitrate plume. There is no Source Assessment Report required chloride. The Tribe also feels that nitrogen concentration used in the mass balance calculations is not correct. The site assumed the nitrate was 20 mg/l when it should be more than 1000 mg/L.

6. Legacy cells leak because they are old. (Cell #1)

The Tribe thinks that the leak in 2009 from Cell #1 one was catastrophic and demonstrates that the cell linings are failing. The PVC pipe that was designed to catch leaks and only works if there is a catastrophic leak. When this occurred, the Mill dropped the liquid levels in the cell and photographed the damage beneath the liquid level. In the Tribes view, this shows that the cell lining failed and the damage was not simply due to sunlight exposure.(The Company has a different view of this event, see notes).

The Tribe is concerned about the potential residual contamination remaining beneath old Roberts Pond, which was used as a catchment for run-off, spills, etc from Mill operations. . In their view, Roberts Pond was excavated because of the lawsuit by Grand Canyon Trust which claimed there were too many active cells on the Mill site. The material in Roberts Pond was excavated to Cell #3. Roberts Pond was either unlined or poorly-lined as was revealed by a gamma survey from the surface. A survey found damaged liner in some places. The Tribe is concerned that verification sampling was not adequate and also that there may be a groundwater mound in that area as suggested by the analysis by Geo-Logic..

7. Water balance model:

The Tribe wants a water balance for the Mill which shows what amounts of water are being used for processing, how much water goes into the aquifer, etc. They believe that the process water is taken from the aquifer instead of Recapture reservoir. (However the site says this is no longer true. During the drought when levels in the reservoir were low, they began using water from the aquifer, but now they are using the reservoir water again.)

8. **MNA:** Colin asked if MNA had been applied to an unconfined aquifer on z Mesa of this size.

9. Comments on my Report

The Tribes' lawyer asked that 1) not use term "weight of evidence" because of legal implications and 2) have 'robust qualifiers' for my conclusions.

Other notes:

An underlying issue appears to be that the Tribe does not feel it is getting enough respect from the different agencies including the state and the EPA. This might be evaluated by the BIA expert on tribal relations through interviews with key participants. I could help get this started through a follow-up task.

List of follow-on activities.

1. Detailed review of Geo-Logic model for alternative hypothesis for natural variability. Independent modeling using PHREEQC to determine if pyrite dissolution can be occurring and caused the pH changes when using ANP estimates.
2. Work with Bureau hydrologist to evaluate alternative travel time estimates.
3. Work with Bureau sociologist to evaluate problems with communication between tribe and regulatory agencies. This would involve interviews with the key participants and a trip to Salt Lake to talk to regulators.
4. Health effects: The Tribe feels that EPA did not want an exposure assessment done for this site and wants to avoid looking at human health implications of the issues that the Tribe raises. The Tribe feels that the health effects associated with the Monticello Mill are relevant to their population. The information from that site should be reviewed to see if that is a valid comparison.
5. Review of Final ICTM and Reclamation Plan to see how questions raised in this contract have been resolved.

Notes from meeting with staff from Energy Fuels Resources (USA) Inc.
November 1, 2016; White Mesa, UT.

Participants:

- Malcolm Siegel, LJS Consulting, Inc.
- Harold Roberts, Exec VP, Energy Fuels Resources (USA) Inc.
- David Frdenlund, Sr. VP, General Counsel, Energy Fuels Resources (USA) Inc.
- Mark Chalmers, COO, Energy Fuels Resources (USA) Inc.
- additional participant from EFR

1. Response to UMUT EPD staff comments about the GWCL chart used by Intera:
The GWCL flow chart does have an "off ramp" that leads to a Corrective Action.
It would be useful to review the Ground Water Discharge Permit to see how Corrective Action is triggered. When an **OOC** happens, the SAR is required and that will lead to the either CA or a change in GWCL.

2. Natural variability debate:
Stewart Smith (HydroGeochem) developed the pyrite argument.
The oxygen in saturated zone waters comes from stressing the wells. When they dewater the wells, the cone of depression allows air to mix with the water. The wells are screened above the water line. The State has accepted this as a "reasonable" idea. The main arguments in favor of this are:

- the decreases in pH are observed site-wide; effects in MW 18 (which is upgradient) and MW-3 (down-gradient) are the most pronounced. The differences in the observed effect at different wells might be due to changes in water levels which leads to changes in the residence times of water along the flow path to the wells.
- the chloride plume is not seen upgradient where the pH is also decreasing.

The Mill owner feels the current procedure for setting the GWCLs is too conservative. The State forces reevaluation of the GWCL every time there is an OOC. The company would like to have the GWCL revised every five years during license renewal. They would like to use the trend in pH and metals concentration to calculate the future GWCL that would be expected at that time. The State does not allow this and forces the company to do a Source Assessment Report based on the previous GWCL.

3. Purpose of the ICTM
This model was used in support of cover design and not expected to predict contamination site-wide. The 200 year time was chosen to be consistent with the Atomic Energy Act Appendix A for tailings which require 200 year minimum life but a 1000 year design life. The model resulted in a better design for the cover and the Company is now in agreement with the State. One of the parameters that needed to be examined was the permeability of both cover and the liner in order to prevent a 'bathtub' effect. The calculations carried out described chemical reactions in Tailing Cells 1, 2 and 3 in which the acid reacts with carbonate and sulfate and "gums up" the

flow path. The discussions with the State have moved beyond discussions of the model because they have started a real test in Cell #2 which is in the first phase of reclamation. A test section has been installed to see if the cover cross section is performing as expected at Cell #2. The Company is ready to sign a SCA Stipulated Consent Agreement with the State to prove that the cover works. Before this, there was a lot of debate about how to do a sensitivity analysis that includes a reasonable worst-case scenario. To resolve this debate, the Company said" let's do a test already." There is a document in progress that describes this and it should be released within one month.

4. Travel time debate

The Company feels that travel times across the site are on the order of 1000 years and not 1 year. A horizontal borehole were drilled near MW-22 and many cores were evaluated to look for evidence of fracture by Stewart Smith; there was no evidence for fractures. There is no single document that describes site-wide hydrology. Stewart Smith has done a lot of work on this and calculates travel times the edge of the site of about 1000 years. The offer by the Company to drill three new wells should result some of the questions about fast paths and flow directions. (I should work with the tribe to select the sites for the new wells.)

5. Debate with State about compliance indicators

In the 10+ years since the State took over responsibility for the site from the NRC, the scope of compliance monitoring has changed from 7 wells with 4 indicators to 30 wells with 40 indicators. Currently the State tacitly accepts 4 indicators at the compliance wells but this is not official stance; the State still looks at all 40 indicators that are measured but relies mostly on chloride. The report by University of Utah is used to justify the "natural variability" argument.

6. Reclamation plan.

Because the waste at the site is a byproduct of uranium tailings (11e2 waste) the site is closed permanently at some time in the future. The Site owner must clean everything and put it in the tailing cells including dust in the area from all around the mill. The cover is designed for a 1000 year life and then the site becomes a DOE Legacy Site where there is no active maintenance and is supported by a Perpetual Care Fund.

7. Monitored natural attenuation

MNA might be considered for final remediation of the chloroform plume but is not currently the subject of discussion.

8. Air quality issues: Origin of "contaminated" dust observed by USGS

- Some dust probably comes from the Plateau Buying Station which was a uranium ore buying station in the late 1970s. This was located north of the Mill site; by current standards, this was not a well-regulated operation and could have led to dust pollution.
- The suggestion that uranium dust came from trucks that were not covered is not true. The trucks have been covered since the 1980s but work practices may not have been strict enough. In response to the USGS Report, EFR cleaned up the work areas while not admitting that the dust observed was their responsibility. The cleanup standards used

by the site are more conservative than what is required (5- 15) which means clean up must be to 5 pCi of radium in the first 15cm soil that. The Company cleans the soil such that all radionuclides are equivalent to 5 pCi radium even though the Site area is not residential. Actually the Site is recreational so exposure is not continuous. Details are found in 10CFR 40 part16A.

- The high uranium in the sediments to the south of the site might be from ore from the Cottonwood Mine that was transported along the road by the facility in the 1950 before the county road was rerouted to its current location.
- Dust monitoring procedures: EFR says that the monitors are running at least 75% of the time each quarter according to regulations. In fact, they run 90% of the time as shown by their maintenance records. The maximum downtime at a monitoring site would be six days according to their SOP.
- Air quality is regulated by 3 overlapping standards.NRC standards are mandated by the State for all radionuclides except radon. In addition the EPA has superimposed radon requirements NESHAP, onto the requirements for air quality monitoring of tailings.
- The Minor Source permit from the State deals with particulates [PM10], NOX, SOX, ie. nonrads.
- On site monitoring: the NRC mandates on-site monitoring at 28 locations for natural U, radium-226, thorium-230, lead-210, radon, gamma and thorium 232 in alternate feed materials. 10CFR20 B says this is sufficient for all radionuclides . The site ALARA is 25% of the NRC requirements.
- The Company added stations to monitor as a result of the USGS study but more important at closure the site has to clean up the whole area to background levels. (MARSIMM approach).
- The Company has concerns about reported fraud at USGS Laboratory and they doubt the results of the sagebrush monitoring.

9. Air Quality - Radon emissions

- The Company argues that the wind velocity used by UMUT EPD to calculate Rn emanations from evaporation ponds was unrealistically too high. The wind velocity at the tailings cells is much lower than that measured at the wind monitoring station which is a tower 1 meter tall. In addition, that location is 15 m above the tailing cell surface. Even when there is a breeze at that elevation, the surface of the tailing cells is like a "mirror".
- The Grand Canyon Trust lawsuit concerns Cell#3 where they claimed there have been past radon violations. They based their lawsuit on the fact that data from multiple sampling events were mixed in calculating the Rn emission. This happened because there was a initial violation of >21 pCi and then the site remediated the area where they could place a cover on hotspots. Then the Site measured that area and found that emissions were sufficiently low; they used that value to recalculate average which was then below the limit of 20 pCi. The regulation requires only one measurement per year and if multiple measurements are taken over time, then average for the results must be

reported. The Grand Canyon Trust sued because the Site didn't remeasure all the (27?) sample monitoring sites on the cell.

10. Evidence that Legacy Cells (#1,2,3) are in really bad shape:
The Tribe asserts that the Legacy Cells are beyond their design life (30 yrs),that observed leaks demonstrate that that they leaking routinely, and must be replaced. In 2009, a leak was detected in Tailings Cell #1 which has a single liner and a PVC pipe to collect leaks. As mentioned in the above report from the meeting with the Tribe, the Tribe described the event as a 'catastrophic' leak that shows that the liner needs to be replaced. The Company has a different story: they feel that the leak detection system, although not as sophisticated as that in the newer cells (#4a,4b) worked as designed and indicated that there was (a small volume?) leak at a certain level. The Cell was drained below that level and they couldn't find the leak so they just replaced a huge section of the liner with new materials. They then refilled the tailings cell and there was no more leakage. The Site Reclamation plan requires that Cell #1 be dug up and material placed in a newer cell for final closure at some time in the future.

Summary of Observations from Site Tour: (no photographs were allowed)

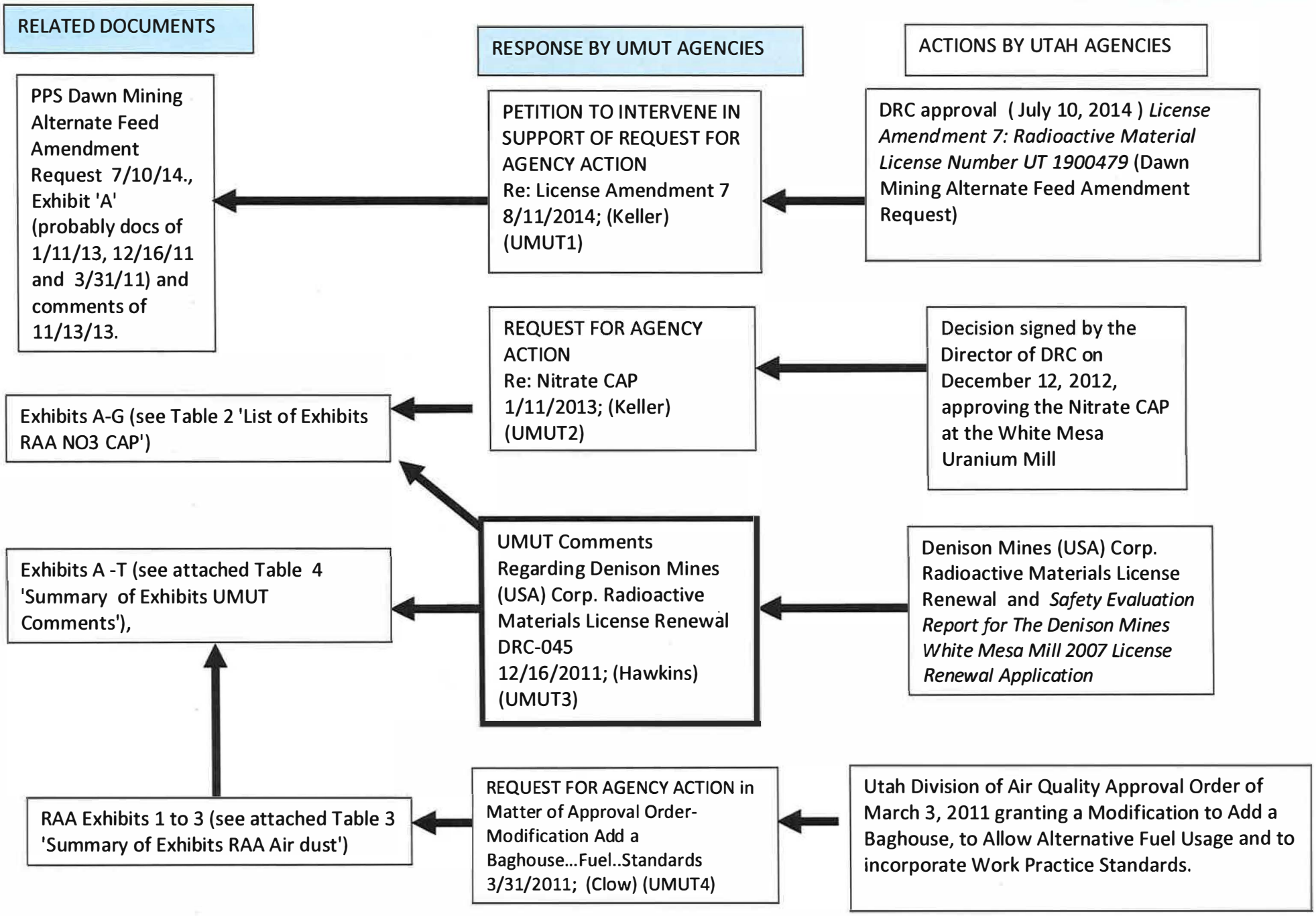
1. Tailings Cell #1- evaporation pond with process water. The surface of the pond is five ft or more below the road.
2. Tailing Cell #2 - all solid; platform cover on part and other parts mushy. This helped me understand the issues behind the Grand Canyon Trust lawsuit.
3. Tailing cell 3- an evaporation pond with a smooth surface
3. Tailing cells 4a and 4 b: "Mirror images" separated by a dike of earth excavated from the cell.
4. Ore storage pads were empty.
5. Wash station to decontaminate the ore trucks when they are ready to leave the site requires multiple washings and scanning.
6. Alternate waste forms: the waste from Midnight Mine is a precipitate from water treatment that is shipped and stored as bricks in double sacks; each sack costs about $1000. I saw many different drums having a different waste forms. The disposal of any new alternate waste form must be approved by an amendment to the Site License. The State regulates and protects the new waste forms in contrast to what the Tribe says.

Additional work to suggest:

- Run the ICTM for full 1000 yrs; why didn't they run it that long? It's a useful tool for sensitivity analysis, which should be done with input from the Tribe (as well as the State).
- Review of Reclamation Plan when it is available; I should get help in areas that I am not expert. This would be more relevant than the unguided review that I did.
- Review of Geo-Logic Report and discussion with the author.
- Meet with UDEQ to get their perspective.

- Make a project for a UNM MPH practicum student on sociological -health aspects of the project:. exposure assessment with cultural view.

Figure 1. Level 1 Road Map



Figures 2a to 2c. Flow Charts for Modification of Ground Water Compliance Limits

2a. Partial Roadmap for Groundwater Background Reports

2b. Groundwater Data Preparation and Statistical Process Flow for Calculating Groundwater Protection Standards White Mesa Mill Site, San Juan County, Utah (from Revised Background Groundwater Quality Report: Existing Wells For Denison Mines (USA) Corp.'s White Mesa Mill Site, San Juan County, Utah, October 2007,"

2c. Flow Chart for GWCL Modification and Challenges by the UMUT EDP

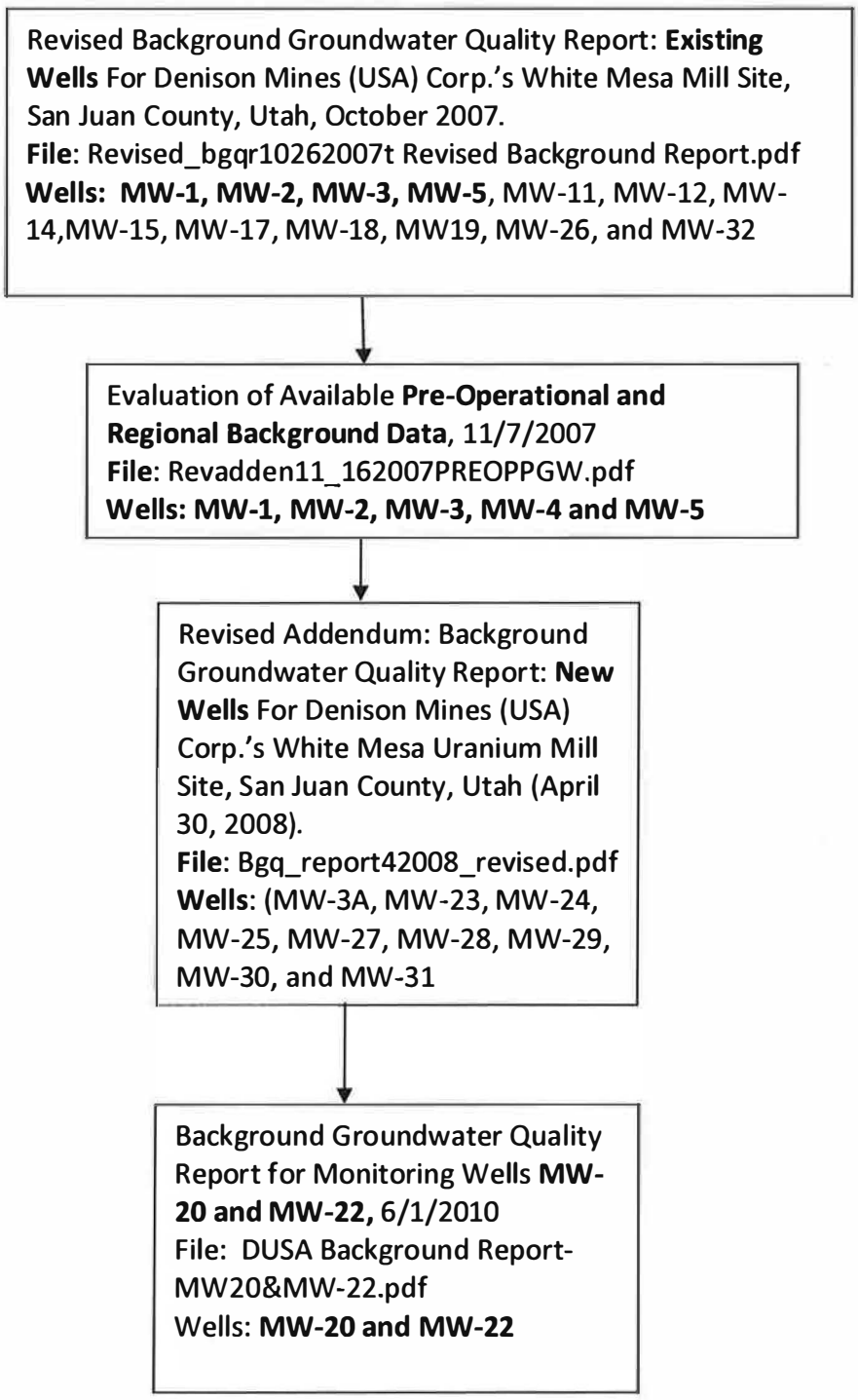


Figure 2a. Partial Road Map for Existing, Regional and Pre-Operational Groundwater Background Reports

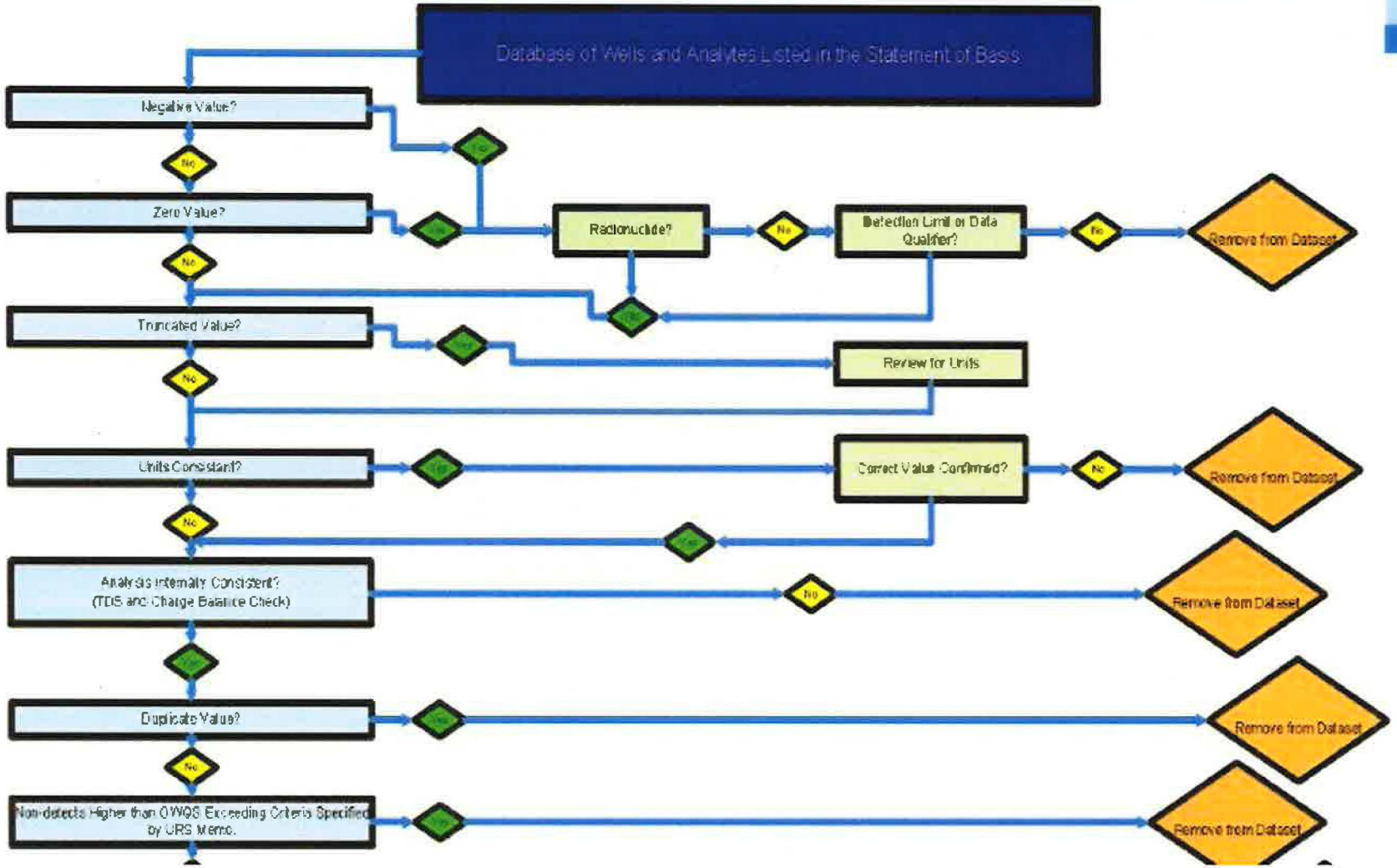
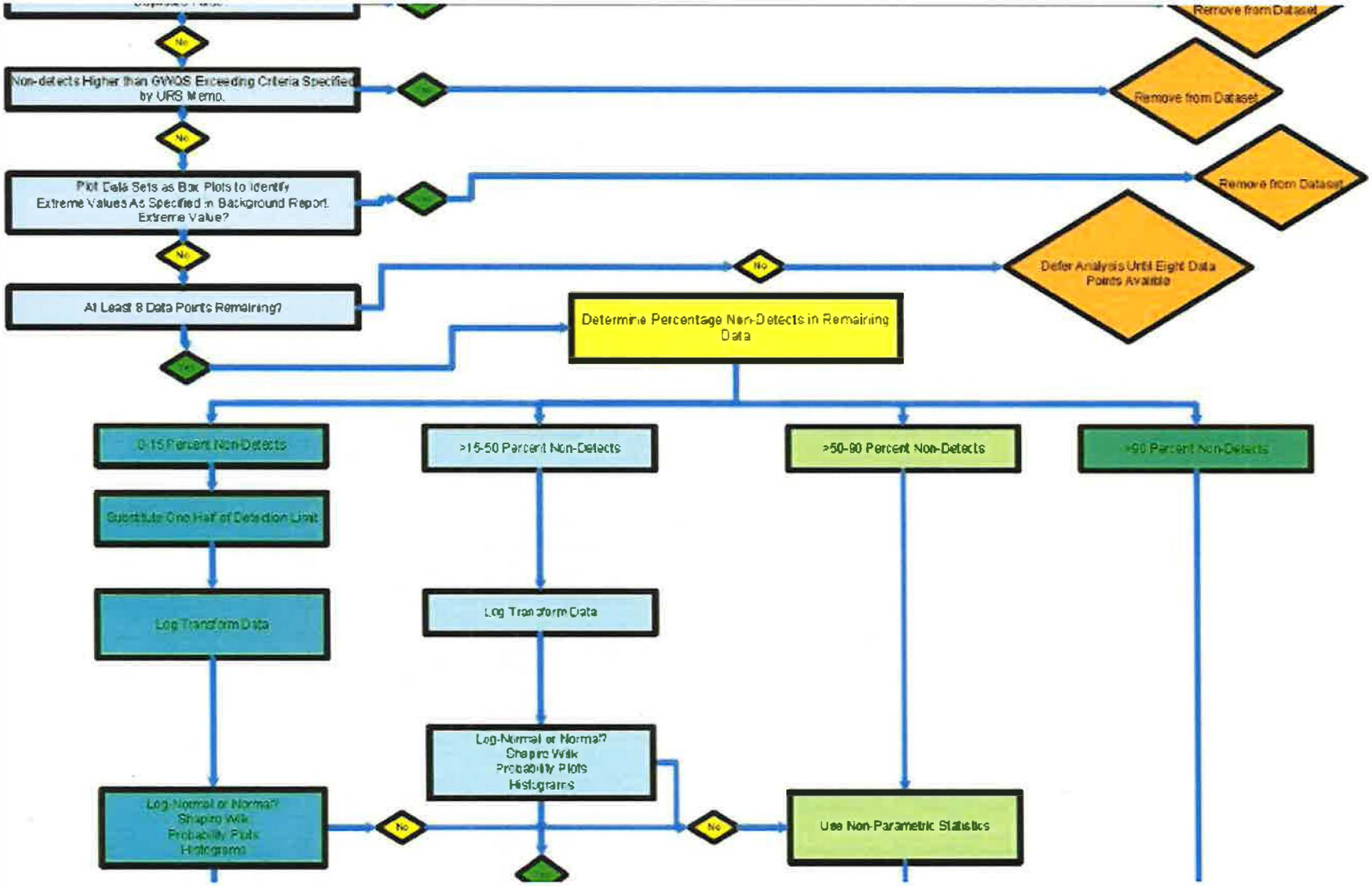
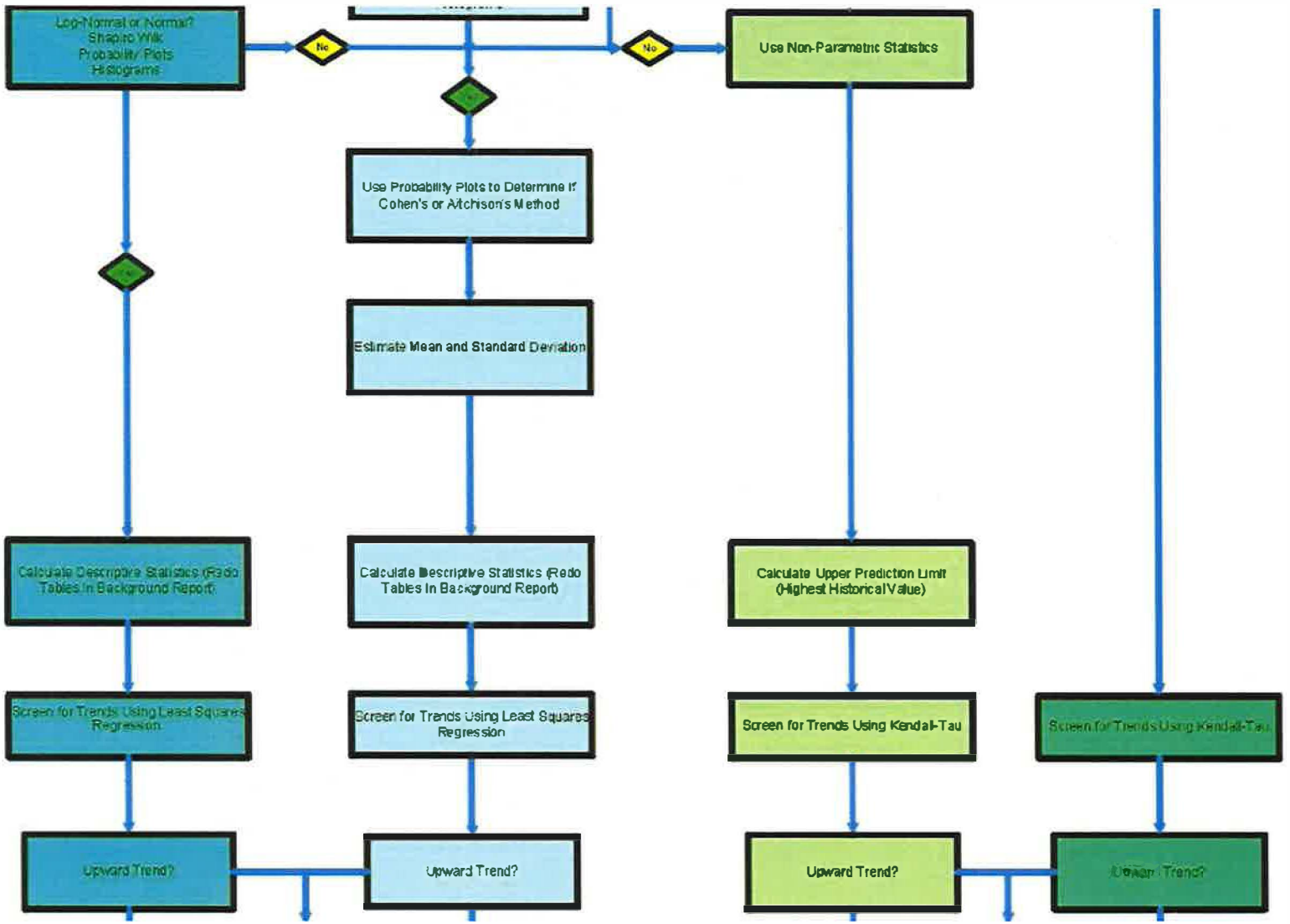


Figure 2b. Groundwater Data Preparation and Statistical Process Flow for Calculating Groundwater Protection Standards White Mesa Mill Site, San Juan County, Utah (Part 1)



Groundwater Data Preparation and Statistical Process Flow for Calculating Groundwater Protection Standards White Mesa Mill Site, San Juan County, Utah (Part 2- Fig 2b)



Groundwater Data Preparation and Statistical Process Flow for Calculating Groundwater Protection Standards White Mesa Mill Site, San Juan County, Utah (Part 3- Fig 2b)

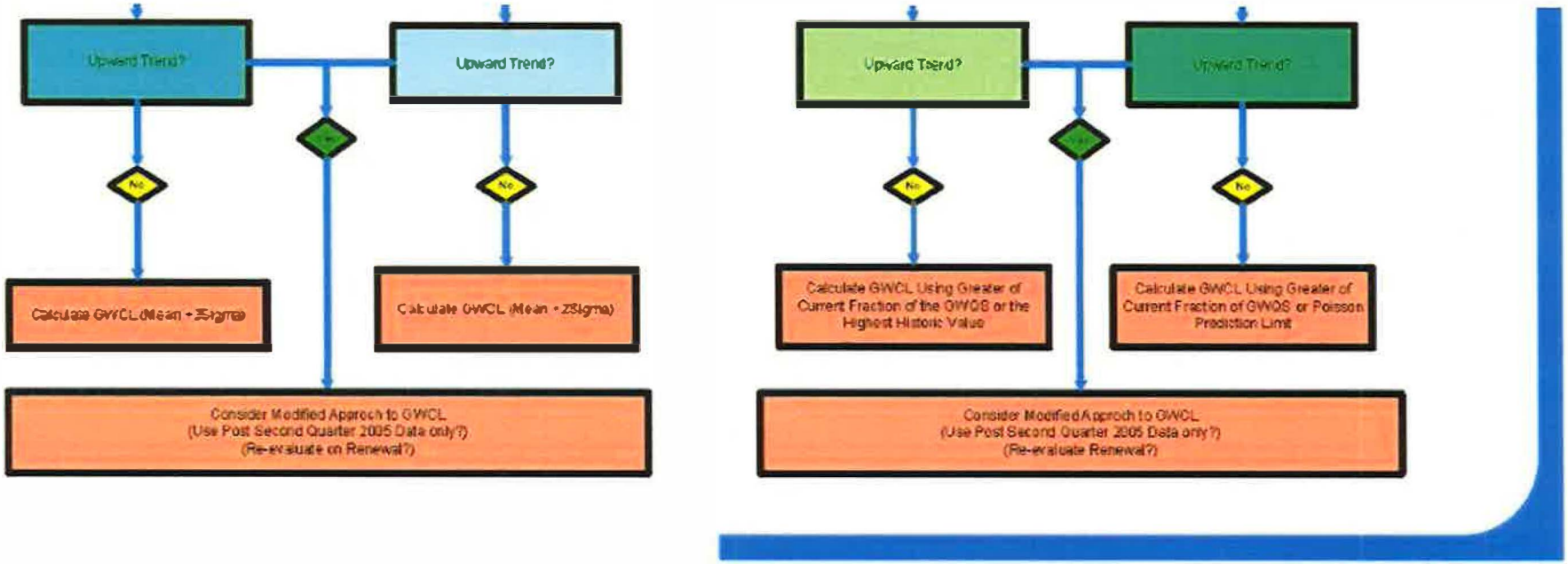


Figure 19
Groundwater Data Preperation and Statistical Process Flow for Calculating Groundwater Protection Standards, White Mesa Mill Site, San Juan County, Utah

Groundwater Data Preparation and Statistical Process Flow for Calculating Groundwater Protection Standards White Mesa Mill Site, San Juan County, Utah (Part 4- Fig 2b)

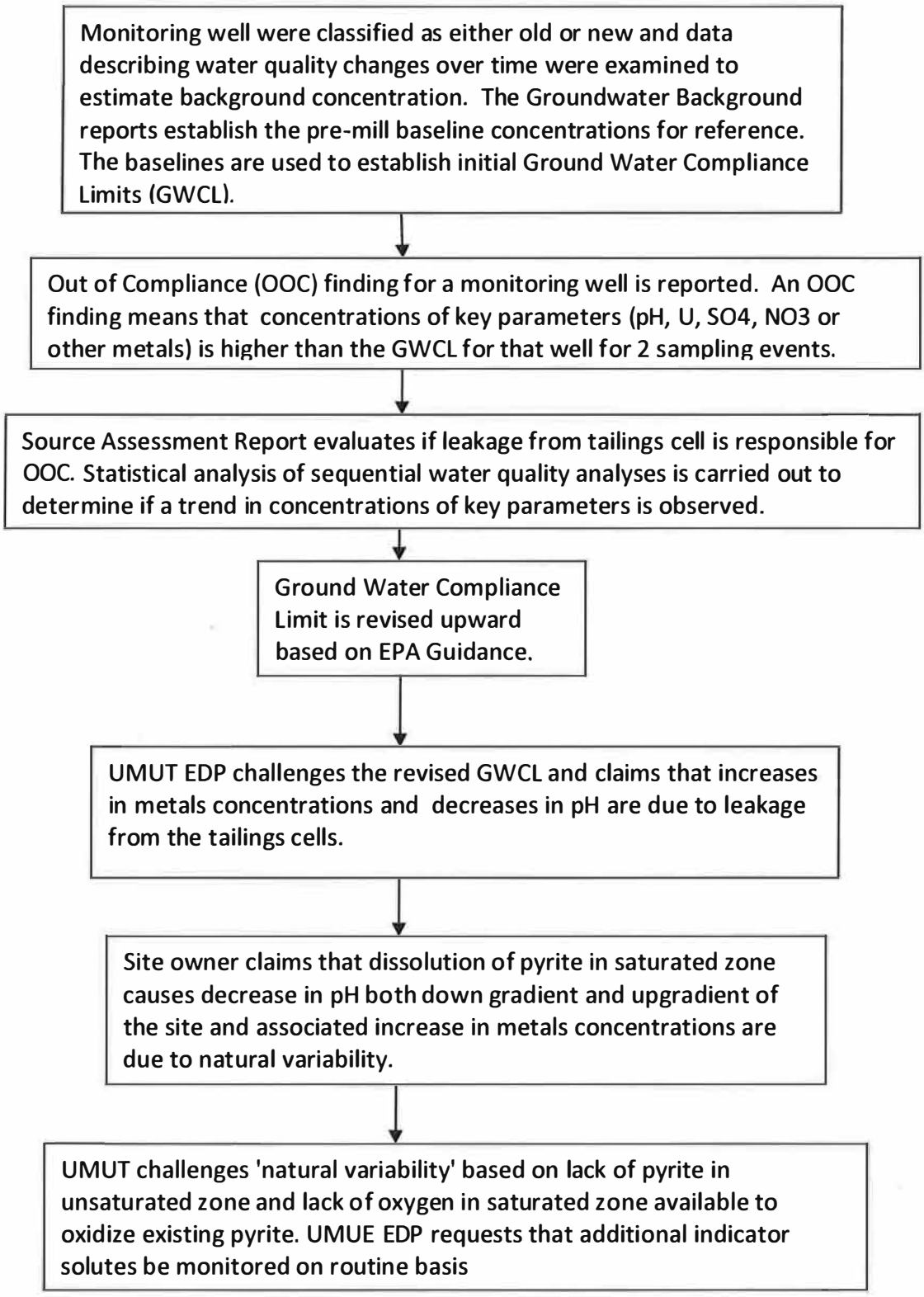


Figure 2c. Flow Chart for GWCL Modification and Challenges by the UMUT EDP

TABLES 1-4

Table 1. Summary of Roadmap Level 1 Documents

Date	Document Title	Author/Recipient	Main points	Referenced by: Refers to: Document #
8/11/2014	PETITION TO INTERVENE IN SUPPORT OF REQUEST FOR AGENCY ACTION Contesting the Utah Division of Radiation Control's ("DRC") decision approving the July 10, 2014 *License Amendment 7: Radioactive Material License Number UT 1900479* (also referred to as the Dawn Mining Alternate Feed Amendment Request)	From: H. Michael Keller (Special Counsel Ute Mountain Ute Tribe) To: Utah DEQ	II. Tribe has legal interests in Amendment 7. DRC's approval of License Amendment 7, is contrary to applicable law, is arbitrary and capricious and beyond the tolerable limits of reason,.. failure and refusal to properly evaluate the environmental impacts of .. or to..minimizes danger to public health and safety or the environment… require EFRI to address ongoing and uncontrolled contamination and serious operational deficiencies at the WMM facility) prior to issuing License Amendment 7. Request: 1) determinations in response to Tribes comments at PPS be reversed and vacated , 2) approval of License Amendment 7 be reversed and remanded to DRC that DRC only renew the RML after EFRI has addressed their concerns..	Ref to: 1. License Amendment 7 (to Radioactive Material License Number UT 1900479). 2. PPS Summary, License Amendment, July 10, 2014. 3. CAP NO3 RAA? 4. UMUT comments on RML Renewal (12/16/11) 5. UMUTs 'extensive public comments of October 13, 2013' 6. 'Exhibit A?' - probably 2-4 above.
1/11/2013	REQUEST FOR AGENCY ACTION - In the Matter of: Stipulation and Consent Order, Docket No. UGW12-04, Regarding Approval and Stipulations for the Energy Fuels Resources (USA) Inc. May 7, 2012 *Corrective Action Plan for Nitrate, White Mesa Mill*	From: Michael Keller (Special Counsel Ute Mountain Ute Tribe) To: Utah DEQ	Contests the Decision, signed by the Director of DRC on December 12, 2012, approving the Nitrate CAP at the White Mesa Uranium Mill ("WMM") and responses to the Tribe's public comments. " DRC has also issued determinations in the Public Participation Summary (and in support of the Nitrate CAP) that are not supported by substantial evidence when viewed in light of the whole record, that	Exhibit A: December 16, 2011 RML Comments Exhibit B: April 2012 Letter Exhibit C:August 2012 Nitrate CAP Comments Exhibit D: Stipulated Consent Agreement,

	)		are arbitrary and capricious, and that are beyond the tolerable limits of reason." In its December 2011 RML Comments, the August 2012 Nitrate CAP Comments, and the April 2012 and October 2012 Letters, the Tribe has provided DRC (Exhibits A, B, C, and E) a detailed analysis of its concerns with groundwater contamination at the WMM facility.	Docket No. UGW12-03 Exhibit E:October 2012 Letter Exhibit F: Initial List of Factual Inaccuracies Exhibit G: Excerpt from Tailings Cell 1 Repair Photographs
12/16/2011	Comments Regarding Denison Mines (USA) Corp. Radioactive Materials License Renewal DRC-045 (a.k.a UMUT Searchable Comment Letter)	From: Celene Hawkins Associate General Counsel Ute Mountain Ute Tribe and H. Michael Keller Special Counsel Ute Mountain Ute Tribe/ To: Rusty Lundberg Director Utah Division of Radiation Control	II. Regulatory issues III(A) groundwater contamination; III(B) air deposition/surface contamination; and III(C) special contamination issues with alternative feed materials. IV(A) DUSA's reclamation plan not protective health of Ute'. IV(B) RML Renewal fails to provide adequate surety.	Referred by: RAA NO3 CAP (Table 2) Refers to: Exhibits A - T. (see Table 3)
3/31/2011	REQUEST FOR AGENCY ACTION in Matter of Approval Order of March 3, 2011 granting a Modification to Add a Baghouse, to Allow Alternative Fuel Usage and to incorporate Work Practice Standards.	From: S. Clow, UMUT EPD To: Utah Air Quality Board	UMUT contests AO of 3/2/11 to authorize mod to add Baghouse, alt fuel usage and work practice stds. It fails to comply with Clean Air Act and other Utah regs. 1. Work Practice Stds for Control Fugitive Dust 2. Provisions insufficient to minimize fugitive dust and protect tribe. 3. no BACT for fugitive dust control	Ref to: 1. USGS report (Ex L UMUT3). 2. multiple amendments to AOs. 3. DAQ Memo in Response to Comments (2/24/2011) 4. Exhibit 1: Moab Site Dust Plan (2002)

			4. Feb 24 memo not address Tribe's comments 5. DAQ **does** have authority to regulate this	5. Crescent Junction Dust Plan (7/2006) 6. Work Practice Stds for Control of Fugitive Dust (no date)

Table 2. List of Exhibits Supporting RAA Nitrate CAP

Exhibit	Title
Exhibit A	Comments Regarding Denison Mines (USA) Corp. Radioactive Materials License Renewal DRC-045
Exhibit B	April 2012 Letter: *Letter from Scott Clow to Rusty Lundberg Re: Follow Up on Groundwater Issues; Denison Mines (USA) Corp. Radioactive Materials License Renewal DRC-045*
Exhibit C	August 2012 Nitrate CAP Comments: *Comments Regarding Denison Mines (USA) Corp., White Mesa Uranium Mill Corrective Action Plan, UGW12-04*
Exhibit D	Stipulated Consent Agreement, Docket No. UGW12-03
Exhibit E	October 2012 Letter: *Letter from Scott Clow to Rusty Lundberg Re: Transfer Action and New Groundwater Enforcement Action UGW12-03, White Mesa Uranium Mill*
Exhibit F	Initial List of Factual Inaccuracies:*"extensive list of the factual inaccuracies contained in the Public Participation Summary"*
Exhibit G	Excerpt from Tailings Cell 1 Repair Photographs DMT Performance Standards Monitoring Report and Cell 4A BAT Performance Standards Monitoring Report for the 2nd Quarter of 2012 (August 22, 2012) [hereinafter "DMT Report"]. Page 427 of Appendix 5. (Repair Photographs)

Table 3. Summary Documents Supporting 'RAA Air Quality/dust'

Date	Document Title	Author/Recipient	Main points	Referenced by: Refers to: Document #
3/31/11	Exhibit B: Request for Agency Action In the Matter of: Approval Order-Modification to Add a Baghouse, to Allow Alternative Fuel Usage and to Incorporate Work Practice Standards- Denison Mines (USA) Corporation, White Mesa Mill.	From: Scott Clow UMUT EPD To: Utah DEQ Air Quality Board	UMUT contests AO of 3/2/11 to authorize mod to add Baghouse, alt fuel usage and work practice stds. It fails to comply with Clean Air Act and other Utah regs. 1. Work Practice Stds for Control Fugitive Dust 2. Provisions insufficient to minimize fugitive dust and protect tribe. 3. no BACT for fugitive dust control 4. Feb 24 memo not address Tribe's comments 5. DAQ **does** have authority to regulate this. Requests: 1) AQ rescind March AO 2) acknowledge jurisdiction for dust control 3) Review USGS report for off-site migration 4) undertake and require BACT analysis by DUSA 5) revise AO to require that work stds provide monitoring etc of dust.	Ref to: 1. USGS report (Ex L in UMUT3). 2. multiple amendments to AOs. 3. UMUT EPD memo of June 2007 re: dust event. 4. 9/4/2007 UMUT letter to DAQ re: human health threat of dust. 5. DAQ memo of 2/24/11 response 6. Exhibits 1-3 below
2/24/2011	DAQ Memo in Response to UMUT Comments	Need to obtain		
3/2002	Exhibit 1: Moab Project Site Fugitive Dust Control Plan GJO-20020301-TAR, GJO-MOA 1.7-1	USDOE Idaho Operations Office Grand Junction Office	Fugitive Dust Control Plan (Plan) to address the control of fugitive and airborne dustemissions from the Moab Project Site (Moab Site) Moab, Utah.	Fugitive dust standards and action levels.
7/2006	Exhibit 2: Crescent Junction Dust Plan; DOE-EM/GJ1235-2006	DOE Office of Environmental	Fugitive Dust Control Plan (Plan) addresses the control of fugitive and	Numerous DOE, NRC, docs, MSD

		Management - Grand Junction	airborne dust emissions from the Crescent Junction Site of the Moab, Utah, Uranium Mill Tailings Remedial Action (UMTRA) Project, located approximately 1.5 miles northeast of Crescent Junction, Utah.	sheets for dust suppressants. Fugitive dust standards and action levels.
No date	Exhibit 3: White Mill Mesa Work Practice Standards for Control of Fugitive Dust: Ore Receipt and Front Loader Operations	DUSA?	2.5 page document that refers to 10 and 15% opacity limits used to monitor activities and data recording requiments.	Approval Order DAQE-AN0112050008-08

Table 4. Summary Of Exhibits UMUT Comments					
Date	Document Title		Author/Recipient	Main points	Referenced by: Refers to: Document #
1. 4/6/2011 2. 11/2/11 3. 11/5/11	Exhibit A: Government-to-Government Correspondence, UMUT/DEQ		1. From: A. Smith (DEQ) To: R. Jenks (Ute Tribe)(wrong Tribe) 2. From: S. Clow (UMUT EP) To: A. Smith (DEQ) 3.from: A. Smith (DEQ) to: S. Clow (UMUT EPD)	1. Migration of Fugitive Dust 2. Insufficient regulation of radon 3. Tailing cell failures and inadequate leak detection system 4. Inadequate closure plan 5. Inadequate financial security (at least an order of magnitude. (doc 3 answers doc2)	Ref to: 1. Stipulated Consent Agreement (9/30/11). 2. CAP for NO3 3. Infiltration and Contaminant Transport Modeling Plan. 4. Reclamation Plan
3/31/11	Exhibit B: Request for Agency Action IN the Matter of Approval Order Modification to Add a Baghouse, to Allow Alternative Fuel Usage and to Incorporate Work Practice Standards Denison Mines (USA) Corporation White Mesa Mill		From: Scott Clow UMUT EPD To: Utah DEQ Air Quality Board	UMUT contests AO of 3/2/11 to authorize mod to add Baghouse, alt fuel usage and work practice stds. It fails to comply with Clean Air Act and other Utah regs. 1. Work Practice Stds for Control Fugitive Dust 2. Provisions insufficient to minimize fugitive dust and protect tribe. 3. no BACT for fugitive dust control 4. Feb 24 memo not address Tribe's comments 5. DAQ **does** have authority to regulate this	Ref to: 1. USGS report (Ex L below). 2. multiple amendments to AOs. 3. DAQ Memo in Response to Comments (2/24/2011) 4. Exhibit 1: Moab Site Dust Plan (2002) 5. Exhibit 2 Crescent Junction Dust Plan (2006) 6. Exhibit 3. Work Practice Stds for Control of Fugitive

					Dust
	Exhibit C: Identification of Potential Tailings Cell Influence in Groundwater at White Mesa Mill		From: UMUT EPD To: Utah DRC	EDP: assessment indicates that contamination originating from the tailings cells is present in the groundwater at the southern boundary of the Mill's monitoring network. DUSA's groundwater travel time of 0.33-0.43 feet per year is not scientifically supportable due to indications of modern water in the well	Refers to:
2/11/99	Exhibit D: February 11, 1999 Letter to David C. Frydenlund (VP DUSA)		From: Sinclair; Dir of DRC To: David C. Frydenlund (VP DUSA)	1. For more than a decade, DRC has documented its concerns about groundwater contamination resulting from potential seepage from the tailings impoundments at the WMM. 2. DRC's concern that DUSA was not using "smoking gun" leakage parameters such as "ammonia, *nitrate, nitrite,* molybdenum and sulfate" during the groundwater monitoring (emphasis supplied. 1. Tailings liner systems Cells 1,2,3 inadequate; models used inadequate w/o sensitivity analysis of performance. 2.LDS inadequate to detect all but catastrophic leaks. 3. fracture flow potential decrease travel time from leak to perched aquifer from 1300 yr to a few weeks under worst case conditions. 4. GW Monitoring program inadequate because it doesn't test for relevant	Letters to IUC on 1/8/99 and 1/21/99. Knight Piesold modeling reports of 11/23/98 and 12/31/98.

				organics and inorganics likely present from acid leach processing of uranium ores and Ashland 2 FUSRAP material.	
No date; just table	Exhibit E: Chloride Citations		From: DUSA To: DRC	chloride, nitrate, and nitrite are primary indicators of tailing cell leakage	Refers to several docs: 1981 to 2010.
6/27/2000	Exhibit F: June 27, 2000 Memo to Dane Finerfrock		FROM: Loren Morton, DRC To: Dane Finerfrock	unlikely that any leak detection system exists under Cell 1 and stating that the system under Cells 2 and 3 is "grossly inadequate"). Contains 9 specific problems that DRC wanted IUC to address.	
12/16/2011	Exhibit G: EPD Review of CAP		From UMUT EPD To: DRC (part of review of DUSA RMLR)	Review finds CAP for Nitrate (and Cl) to be deficient because it isn't protective of pH and environment, have permanent effect and ensure that discharge achieves GW Quality stds or ACACLs.	
12/1/2011	Exhibit H: RRD Letter		From M. Smith, RRD; To: C. Hawkins UMUT	The liners in Tailings Cells 1, 2, and 3 have passed their useful life. 1.The thin, 30-mil polyvinyl chloride ("PVC") liners on Tailings Cells 1, 2, and 3 were not best available technology when they were installed in the late 1970s. 2. this type of thin PVC liner cannot last 30 years in an acidic environment. 3. the liners in Tailings Cells 1, 2, and 3 have been further compromised by the placement of incompatible alternative feed material in the cells. 4. the capping ? cost estimate ($17.7M?) that Dension uses is too	Numerous references to literature from 1990s to 2010 from industry studies of liners, barriers, and cost analysis of remediation. Section 2.5 referred to numerous places as basis for recommendations in UMUT II.a.1.i. Comments

				low by a factor of 2.5 to 5 based on comparison with other similar facilities and 2 cost estimating methods.	
2/27/2008	Exhibit I: DOE Letter Re: 2035 DOE Receipt (Closure)		From:M. Owen DOE-LM To: House, UMUT	WMU Mill operates under NRC license and regulated by Utah which is an NRC Agreement state. DOE-LM will take over in 2035.	
9/30/2011	Exhibit J: Amended Stipulated Consent Agreement, September 30, 2011		Signed by D. Frydenlund (DUSA) and R. Lundberg (UWQB)	1. described events from 1/27/2009 to 8/25/2011. 2.requires DUSA to submit CAP for NO3 with 3 phases of activity by 11/30/2011 for approval by Utah Water Quality Board.(UWQB)	
12/16/2011	Exhibit K: Description of the White Mesa Water System		From: UMUT EDP to: DRC (part of review of DUSA RMLR)	2 deep supply wells in Navajo Fm; NV Fm begins at 900 ft; ; static water table in wells is about 450 ft.	
2011	Exhibit L: USGS Report (on disc) Naftz, D.L., Ranalli, A.J., Rowland, R.C., and Marston, T.M., 2011, Assessment of Potential Migration of Radionuclides and Trace Elements from the White Mesa Uranium Mill to the Ute Mountain Ute Reservation and Surrounding Areas, Southeastern Utah: U.S. Geological Survey Science Investigations Report 2011–5231.		USGS Report	Tribe uses report to support assertions: 1. U and V has migrated east of WMM facility 2. offsite migration begins with airborne dust and spread as washed down drainages. 3. concern that this contaminates vegetation, livestock and endangers human health. **Abstract of USGS report** says: 1) young age of water indicates local recharge of shallow aquifer including 'potential' from seepage from constructed wetlands wildlife refuge ponds near the mill. 2) Water in Entrance Spring may come from Recapture Reservoir used on site and	

				by Blanding field irrigation after evaporation. 3) Sulfur isotopes indicate potential contamination link between cells and refuge ponds could be related to aerosols transport; .4) U isotope data indicate mill is not source of uranium in any site monitored but U-isotopes indicate the aeolian transport of small particles from ore storage pads and uncovered ore trucks could occur but only at that site. 5) Entrance Spring is distinguished: highest [U], [Se, V], U-isotope ratios not consistent with natural sources. Plants downwind of mill had *elevated* U and V, *indicating* offsite transport. 6)[U] in GW is not good indicator of contamination because it is affected by local sources, evaporation but soils and vegetation may be better indicator of offsite migration.	
7/6/2012	Exhibit L: DRC Review presentation		DRC_review of USGS report 2012 USGS Report 070612	Summarizes 9 USGS recommendations: DRC agrees with 7 of them, disagrees with 1 and partial agrees with 1.	To Exhibit L
11/16/2011	Exhibit L: USGS presentation on USGS studies		Wed2_6whitemesa Ranalli, Larrick, WREQC team	Summary of USGS report and comparison to results of well studies at Wind River UMTRA site.	To: Exhibit L
12/16/2011	Exhibit M: Bioavailability, Bioaccumulation and Food Chain Transfer of Airborne Radionuclides		From: UMUT EPD to: DRC (part of review of DUSA RMLR)	Basis of Tribes demand for monitoring for airborne samples a ground level. Food chain transfer of U-series U-238; Ra-226, Pb-210; Po-210.; air borne dispersion of dust from tailings. Tribal members traditionally harvest wildlife and plants for consumption and	IAEA (2010)trf172, Thomas (1995, 1997, 1999)- Arctic studies. NM EID (1986) study of livestock near mines and tailings.

				ceremonies. What is likely does under different scenarios? Relevance of Thomas studies and NM EID study from 1986?.	Thomas refs are incomplete. see also IAEA srs19
2/24/2011	Exhibit N: Response Memo (AO) Response to comments on DAQE-IN0112050018-10, Comments from public comment period from various people including the Tribe.		From: M Maung DAQ/DEQ To: Denison White Mesa Source Fi le	AO documents work practices standards to control fugitive dust See IUC/UGW for location and initial permitting of the White Mesa facility: www.radiationcontrol.utah.gov/Uranium_Mills/IUC/Denison_IUC/UGW_renewal.html Clear objections from Tribe based on concern about fugitive dust emission and response from DAQ which rejected the Tribal requests..	Refers to: 0. Exhibit O (draft) 1. UAC R307-410 modeling thresholds for air dispersion modeling 2. State of Utah RadMat License UT 1900479 for stack testing emissions 3. UAC-19-2-107(2)(d) inspections 4. Final Environmental Statement Related to Operation of White Mesa Uranium Project Energy Fuels Nuclear, Inc. 1979
3/2/2011	Exhibit O: Approval Order Modification to add a baghouse, to allow alternate Fuel usage and incorporate work standard practices.		From : Heying (Exec Sec Utah Air Quality Board and Dir DAQ) To: Tischler (DUSA)	Fugitive dust emissions controlled by Workplace practices. 1) opacity at emission points 10% to 20%. 2) PM10 at various emission points 3) Fugitive from roads and equipment in operations areas < 20% opacity 4) unpaved roads and operational areas	R307-401-8 40CFR Part 60 Appendix A, Method 9: observations of emissions.

				kept moist to keep opacity < 20%. 5) record kept for cleaning paved roads 6) requirements made by Exec Secretary. (M. Cheryl Heying).	
12/16/11	Exhibit P: Deficiencies in DUSA's Environmental Monitoring Program		From: UMUT EP To: DRC re: comments of DUSA RML Renewal	1. determine why the monitoring did not detect the airborne migration of Radioactive Material 2. Provides initial technical comments on improvements to the semi-annual effluent monitoring program. Failures: water and soil sample location; air sample location; estimate of background; not enough rads isotopes; poor QA/QC/SOP systems; bias and nonobjective monitoring program. 3. provides refs on bio-uptake of rads	By: UMUT Comments B.2.a p. 16.
Various 1999: 1: 4/16/99 2: 4/7/99 3: 3/9/99 4: 2/11/99 5: 1/21/99 6: 2/12/99	Exhibit Q: Brown Letter with Attachments CERCLA off-site rule (OFR) determination		1. From: Herbert (DRC) To: Nielson (DRC) 2. From: Sinclair (DRC) To: T. Brown (EPA-8) 3-6: other letters between IUSA, DRC, consultant, Utah AG office.	UMUT Comment Letter: DRC's concern with liner incompatibility with alternative feed materials. Summary: DRC wants IUSA to get GW discharge permit. Letters deal with: 3: alternate feed materials concerns 4: GW protection from potential seepage 5: DRC questions validity of assumption in model for Cell 3 lining system 6: Consultant to IUSA defends modeling : 1300 y travel time from liner to perched water zone.	by: UMUTC.1.a p19 to: 1. Knight Piesold (1998) *Methodology for Calculation of Flux Through the Cell Liner, Dec 31, 1998.* 2. Titan Environmental Report (1994) *Hydrogeologic Evaluation of White Mesa Uranium Mill*
12/16/2011	Exhibit R: Particular Concerns with Alternative Feed Material		From: UMUT EPD	1. DUSA is Not Properly Monitoring Disbursement of Components of the	

				Alternative Feed Material 2. Alternative Feed Material is More Susceptible to Wind Dispersion than Other Licensed Materials at the WMM Facility. 3. DUSA is Not Properly Modeling the Dose Assessment of Alternative Feed Material.	
3/28/2003	Exhibit S: Sampling Memo : Sampling Results from Passive Diffusion Bag Samplers, August 14, 2002 GW Split Sampling Event at IUC WMU Mill: DRC Results, Findings and Request for Action		To: H. Roberst (VP Int. Uranium Corp) From: WJ Sinclair (DEQ/DRC).	1. Dissolved VOC contaminant plume in Wells but not DNAPL 2) VOC analytic methods improvement needed: MDLs for 6 VOCs need to be implemented to allow determination whether State GWQS had been exceeded. 3) need to add 3 new VOCs to list 4) a THM compound is not really there 5) request continued cooperation in characterization and cleanup of a the VOC plume.	Refers to: 1) 5/3/02 IUC PDP Sampler Work Plan 2) DRC worksheets PDBagags.xls (missing),
12/16/11	Exhibit T: Reclamation Plan Deficiencies		From: UMUT EPD '	1. Reclamation Plan Provisions for Reclaiming Cell 1 Are Insufficient Clay liner insufficient Storm water sediments basin leads to water seepage into waste. 2. Storm Water Discharge Channel West of Cell 1 Violates the Storm Water Management Plan and Risks Contaminating Westwater Creek with Radioactive Material from the Mill Yard 3. Reclamation Plan Needs Clarification on Placement of	Ref by: UMUT Ref to: 1. Attachment A, Plans and Technical Specifications for Reclamation for White Mesa Mill Facility, Blanding Utah 2. RRD Letter (Exhibit H above) 3. Storm Water

				Contaminated Soil a. all contaminated soils should go into the last operational tailings disposal cell. b. require that all contaminated soil be placed in the last operational tailings disposal cell c. It should be clear exactly where the contaminated soils, raffinate crystals from Cell 1 and other radioactive materials are to be disposed of permanently. Reclamation Plan 5.0 offers too much flexibility in the locations of radioactive material disposal 4. Scoping Survey Is Insufficient a. 90% of the facility unscanned at best b. should be conducted across the entire facility and adjacent property such as the highway right of way not only in areas expected to be contaminated . c. relies on antiquated data to determine the radium "background" as 0.93 pCi/g from 16 years of monitoring conducted during the 1980's and 1990's when 5. Soil Sampling Plan is Insufficient a. 30m x 30m grid sampling , 10% effective scoping survey , averaged over "any" 100m2 are not defensible because of infinite number of potential calculations for compliance assessment.	Management Best Practices Plan 4. White Mesa Mill Tailings Reclamation, Sediment Basin Design, sheet REC-3, MWH, 09/2011

				6. Animal Intrusion Analysis is Weak a. reclaimed cell caps will likely become good habitat once again.	