Focused Review of Specific Remediation Issues

An Addendum to the Remediation System Evaluation
for the
Homestake Mining Company (Grants) Superfund Site, New Mexico

Final Report
December 23, 2010

Prepared by US Army Corps of Engineers
Environmental and Munitions Center of Expertise
For US Environmental Protection Agency, Region 6

US Army Corps of Engineers
Environmental and Munitions
Center of Expertise

US Environmental
Protection Agency

Executive Summary

The current evaluation of the remediation efforts at the Homestake Mining Company (Grants) Superfund site has been conducted on behalf of the US Environmental Protection Agency (US EPA) by the US Army Corps of Engineers Environmental and Munitions Center of Expertise. The evaluation is intended to supplement the previous Remediation System Evaluation (RSE) conducted for the site by Environmental Quality Management (EQM, 2008). Specific issues remaining from the RSE, as identified in the Scope of Work (Appendix A), have been addressed through data analysis and conceptual design, including:

1) Evaluate the capture of contaminant plumes in the alluvial and Chinle aquifers.
2) Evaluate the overall strategy of flushing contaminants from the large tailings pile with discharge of wastes to on-site evaporation ponds and to identify and compare alternatives.
3) Assess potential modifications to the current ground water treatment plant to improve capacity.
4) Evaluate the projected evaporation rates for the existing on-site ponds and for a proposed evaporation pond west of the on-site tailings piles, as it may affect the restoration activities at the site.
5) Assess the adequacy of the monitoring network at the site.
6) Evaluate the current practice of irrigating with untreated water.
7) Evaluate the smaller of the two tailings piles at the site as a potential source of contamination and the future need for a more conservative cap than the radon barrier.

A process fostering involvement and input from various stakeholders had been developed soon after the initiation of the project and has been very helpful in focusing and facilitating the analysis.

The analysis of current and past environmental conditions as well as the current and past operations of the extraction, injection, and treatment systems has been conducted by the USACE EM CX following a site visit in April, 2009. It appears that the current remediation systems have been making significant progress in improving ground water quality at the site and Homestake Mining Company has been diligently working in good faith toward restoring the environment. There are a number of major conclusions from the evaluation of the efforts.

- Ground water quality restoration is very unlikely to be achieved by 2017 with the current strategy.

- Flushing of the large tailings pile is unlikely to be fully successful at removing most of the original pore fluids or to remediate the source mass present in the pile due to heterogeneity of the materials.

- Long screened intervals in wells complicate the interpretation of water quality in and below the large tailings pile.

- The vicinity of the former mill site may be an additional source of contaminants.

- Control of the contaminant ground water plumes seems to depend on both hydraulic capture and dilution.

- There may have been widespread impacts on the general water quality (e.g., ions such as sulfate) of the alluvial aquifer since mill operations began, but the limited amount of historical data precludes certainty in this conclusion.

- Upgradient water quality has declined over time, primarily in the western portion of the San Mateo drainage and this may be affecting concentrations in northwestern portions of the study area.

- Ground water modeling has generally been done in accordance with standard practice. The seepage modeling likely overestimates the efficiency of flushing of the tailings.

- The control of a uranium plume in the Middle Chinle aquifer may be incomplete.

- There are no readily apparent site-related impacts to the San Andres aquifer though data are limited. San Andres well 0943, located at the western end of Broadview Acres, had an increase in uranium concentrations in 2002, but concentrations since then have been relatively stable.

- There is no indirect evidence of leakage from the evaporation and collection ponds, though the interpretation of water level and concentration data are complicated by the significant injection and extraction conducted in the immediate vicinity of the ponds.

- Current constraints to treatment plant operations include the evaporative capacity of the ponds, clarifier operations, and possibly reverse osmosis capacity.

- Evaporation rates for the ponds at the site are likely to be in the 65-80 gpm on an annual basis when accounting for climatic conditions and salinity of the pond contents.

- The monitoring program at the site is extensive and not clearly tied to objectives. There may be redundancies in the network in a number of locations in the alluvial aquifer. Additional monitoring points are necessary in the Upper and Middle Chinle aquifers to better define plume extent and migration. Monitoring frequency is irregular but generally from semi-annual to annual. Air particulate monitoring appears adequate to assess anticipated effluent releases from the site; however, there is a need to confirm assumptions. The potential for release of radon from the STP/evaporation pond area should be assessed.

- Irrigation with contaminated water has resulted in accumulation of site contaminants in the soil of the irrigated land. These accumulations are unlikely to migrate to the water table over time, however.

- Water used for irrigation could be successfully treated with a two-step ion-exchange process.

Based on the analysis conducted, a number of recommendations are offered.

- The flushing of the tailings pile should be ended. If this is not adopted, a pilot test of the potential for rebound in concentrations should be conducted in a portion of the tailings pile. Monitoring should be conducted in depth-specific wells with short screen lengths.

- Simplification of the extraction and injection system is necessary to better focus on capture of the flux from under the piles and to significantly reduce dilution as a component of the remedy.

- Further evaluate capture of contaminants west of the northwestern corner of the large tailings pile.

- If not previously assessed, consider investigating the potential for contaminant mass loading on the ground water in the vicinity of the former mill site.

- Additional collection of geochemical parameters, including dissolved oxygen and oxidation reduction potential, of the groundwater beneath and downgradient of the LTP to characterize the geochemical environment and the role that reducing conditions induced by the flushing have had in immobilization of the selenium (and the potential that cessation of the flushing may lead to less reducing conditions and release of the selenium).

- If the field pilots to reduce uranium concentrations in the groundwater through adsorption or in-situ precipitation are approved and the results from the pilots are promising, apply in larger scale to applicable portions of the LTP and the groundwater.

- Further investigate the extent of contaminants, particularly uranium, in the Upper and Middle Chinle aquifers and resolve questions regarding dramatically different water levels among wells in the Middle Chinle.

- Consider geophysical techniques, such as electrical resistivity tomography to assess leakage under the evaporation ponds.

- Assure decommissioning of any potentially compromised wells screened in the San Andres Formation is completed as soon as possible.

- Consider construction of a slurry wall around the site to control contaminant migration from the tailings piles. The decision for implementing such an alternative would depend on the economics of the situation. Note that HMC has reportedly considered a slurry wall in the past, and not found the economics favorable. We recommend revisiting this issue in light of current conditions.

- Relocation of the tailings should not be considered further by any means given the risks to the community and workers and the greenhouse gas emissions that would be generated during such work.

- Consider either the pretreatment of high concentration wastes in the collection ponds as is currently being pilot tested, or adding RO capacity to increase treatment plant throughput and reduce discharge to the ponds.

- Review of the spray evaporation equipment and potential optimizations of the equipment to increase the rate and efficiency of evaporation.

- Selection of the area of the additional pond based on the evaporative capacity needed after optimization of the treatment and evaporative spraying systems and operations.

- Develop a comprehensive, regular, and objectives-based monitoring program.

- Quantitative long-term monitoring optimization techniques are highly recommended.

- Adjust Air Monitoring Program to perform sampling of radon decay products to confirm equilibrium assumption, consider use of multiple radon background locations to better represent the distribution of potential concentrations and assess the radon gas potentially released from the evaporation ponds, especially during active spraying.

- Though risks appear minimal with the current irrigation practice, consider treatment of contaminated irrigation water via ion exchange prior to application as a means to remove contaminant mass from the environment.

Table of Contents

Appendices

1 INTRODUCTION

1.1 Brief Chronology of the Remediation System Evaluation (RSE) and RSE Addendum Effort. The US Environmental Protection Agency (EPA) Region 6 had originally requested a review of the performance of the ground water remedy at the Homestake Superfund site. The site was used for milling of uranium ore and includes two tailings piles. The operations and leaching of liquids from the mill site and tailings piles has contaminated ground water in the vicinity of the site.

1.1.1 *Original RSE*. The original RSE for the Homestake Mining Company (Grants) Superfund Site (Homestake Site) was conducted by Environmental Quality Management (EQM) under contract to the EPA Risk Management Research Lab in Cincinnati in 2008. A draft report was submitted in August 2008, and a draft final report was submitted in December, 2008 (EQM, 2008). The draft final report was accompanied by responses to comments provided by various stakeholders, including:

- the State of New Mexico,
- members and consultants of the Bluewater Valley Downstream Alliance (BVDA), and
- Homestake Mining Company.

The RSE report described the site conditions and the current remedy, as well as provided several recommendations. Based on stakeholder comments, EPA determined that there were additional issues that needed to be addressed regarding the implemented remedy at the site. Through Headquarters, US EPA, the US Army Corps of Engineers (USACE) Environmental and Munitions Center of Expertise (EM CX) was tasked to perform a follow-on study (the RSE "Addendum") to address a number of remaining issues.

1.1.2 *RSE Addendum Objectives and Scope of Work*. The goals of the RSE addendum were to consider the following major issues:

- the performance of the current approach to protecting, restoring, and monitoring ground water quality
- the need for changes to the ground water treatment system
- the appropriateness of irrigation of crop land with contaminated groundwater

To accomplish these goals, a scope of work was developed in conjunction with the stakeholders, including those listed above as well as the Pueblo of Acoma and their consultants, the Nuclear Regulatory Commission (NRC), and local residents. The scope of work included seven tasks (generalized below – the complete scope of work is provided as Appendix A):

1) Evaluate the capture of contaminant plumes in the alluvial and Chinle aquifers.
2) Evaluate the overall strategy of flushing contaminants from the large tailings pile with discharge of wastes to on-site evaporation ponds and to identify and compare alternatives.
3) Assess potential modifications to the current ground water treatment plant to improve capacity.
4) Evaluate the projected evaporation rates for the existing on-site ponds and for a proposed evaporation pond west of the on-site tailings piles, as it may affect the restoration activities at the site.
5) Assess the adequacy of the monitoring network at the site.
6) Evaluate the current practice of irrigating with untreated water.
7) Evaluate the smaller of the two tailings piles at the site as a potential source of contamination and the future need for a more conservative cap than the radon barrier.

The organization of this report generally follows this list of tasks.

1.2 USACE RSE Addendum Project Team. The RSE Addendum was prepared by personnel from the USACE EM CX in Omaha, Nebraska, including:

- Dr. Carol Dona, Chemical Engineer
- Mr. Brian Hearty, Health Physicist
- Mr. Dave Becker, Geologist

1.3 RSE Advisory Group. The RSE Addendum effort was significantly aided by input from a diverse and involved group of stakeholders. The representatives of the stakeholders included:

- Acoma Pueblo. Ms. Laura Watchempino, Haaku Water Office
- Blue Valley Downstream Alliance. Ms. Candace Head-Dylla, Mr. Milton Head, Mr. Art Gebeau, Dr. Richard Abitz, consultant to BVDA, Mr. Chris Shuey and Mr. Paul Robinson, Southwest Research and Information Institute, consultants to BVDA and Acoma Pueblo..
- Homestake Mining Co./Barrick Gold, Mr. Al Cox, Mr. Dan Kump, Mr. George Hoffman, Hydro-Engineering LLC, consultant to Homestake
- New Mexico Environment Department. Mr. Jerry Schoeppner, Mr. David Mayerson
- Nuclear Regulatory Commission. Mr. John Buckley
- US EPA. Mr. Sairam Appaji, Remedial Project Manager, Mr. Donn Walters, EPA Region 6 in Dallas, TX; Ms. Kathy Yager, HQ EPA; Dr. Robert Ford, EPA National Risk Management Research Laboratory, Cincinnati, OH

The interaction between EPA, the RSE Addendum team, and the RSE advisory group was governed by a Communications Plan (provided as Appendix B). A joint site visit including the RSE Addendum team and many of the stakeholders was conducted April 21-23, 2009. Subsequently, a number of phone conferences were held to clarify the scope of the RSE Addendum effort, and to report on its progress. Valuable input was obtained through this process.

1.4 Condensed Overview of Site. The previous RSE report provided a general overview of the site conditions and current remediation system. A more complete description is also provided in the Annual Reports provided by Homestake per their NRC license. A brief synopsis of the site history, geology, restoration actions, and restoration requirements is provided below.

1.4.1 *History and Surrounding Land Use*. The HMC Superfund Site is located 5.5 miles north of Milan, New Mexico, along the west side of State Highway 605. The surrounding area is used for residential, agricultural, and commercial purposes. Five low-density residential subdivisions, Murray Acres, Broadview Acres, Pleasant Valley Estates, Felice Acres, and Valle Verde are located within two miles south and southwest of the site. Large areas north and west of the site are largely unused except for grazing. HMC (and, for a period of time early in its history, its corporate partners) operated a uranium ore mill at the site from 1958 until 1990 using alkaline leach methods. Tailings from the mill operations, entrained in solutions from the milling process, were placed into lagoons on the top of two disposal piles at the site. These piles were closed and covered by interim covers upon closure of the mill. Windblown materials from the tailings piles were scraped from surrounding areas and placed on the piles before covering. The mill was decommissioned and demolished between 1993 and 1995. The debris was buried at the former mill site. All work has been conducted under license from the NRC. The site setting is shown on Figure 1a.

1.4.2 *Site Hydrogeology*. The Homestake site is underlain by unconsolidated alluvial materials resting on the incised surface of the Late Triassic Chinle Formation. The alluvial materials are a heterogeneous mixture of sand, silt, and gravel and comprise an aquifer with estimated hydraulic conductivities ranging from 10 to 800 feet/day. Saturated thicknesses range from 0 to over 60 feet in the unconsolidated aquifer, including a filled channel that underlies the large tailings pile. Depth to water is 40-60 feet at the site. Though the Chinle Formation is largely comprised of shale, there are three water-bearing units within the Chinle, including the Upper and Middle Chinle sandstones, and the Lower Chinle "aquifer" consisting of a zone of enhanced water yield. A regional aquifer, the Permian-age San Andres Formation, exists at depth below the site, and predominantly consists of limestone with subsidiary sandstones and shale. The bedrock units have been tilted and faulted in the vicinity of the site. As a result, the different Chinle aquifers are in contact with the base of the overlying alluvial aquifer in areas of the site. Water exchange occurs between the various aquifers and "mixing zones" have been identified between the alluvial aquifer and the Chinle aquifers. Faulting has isolated some segments of the bedrock aquifers from others and from the alluvial aquifer. Refer to the HMC Annual Reports or the RSE report for additional information. Well locations are shown on Figure 1b.

1.4.3 *Contaminants*. Seepage from mill tailings wastes (i.e., Large Tailings Pile and Small Tailings Pile) resulted in the contamination of groundwater with radioactive and non-radioactive contaminants, including uranium, thorium-230, radium-226 and radium-228, selenium, molybdenum, vanadium, sulfate, nitrate, chloride, and total dissolved solids (TDS). Uranium, selenium, and sulfate have particularly impacted downgradient ground water quality. Impacts are most widespread in the alluvial aquifer, but contaminants have been identified in the Upper and Middle Chinle aquifers as well. The concentrations in the alluvial aquifer are highest under and near the large and small tailings piles and the former mill building location. Two plumes of uranium and selenium extend southwestward near and under residential areas along preferential ground water flow paths; one west of the site and the other south-southwest of the site. There have also been impacts on the concentrations of dissolved solids, including sulfate, in the alluvial ground water. Actual impacts by sulfate are difficult to discern from background conditions, as historical data prior to mill operation are limited. Data for samples collected in the 1950s from a couple of alluvial aquifer wells approximate 2.5 miles west of the site (well numbers 0935 and 0936) suggest significant increases in sulfate concentrations have occurred. These wells are located in the Rio San Jose alluvium and the cause for these increases is not known. Sulfate concentrations in samples taken in 1960 from a well near what is now the northwest corner of the large tailings were under 700 mg/L (Head, 2010, Comments on draft report), but are now, according to the 2008 Annual Report, almost triple that in the same general area, suggesting an impact on water quality over time. The proximity to the tailings implicates the pile as the source. Ground water in the alluvial aquifer is expected to be largely aerobic and would enhance the mobility of dissolved uranium and selenium.

The water in the tailings piles is, not surprisingly, highly contaminated. High levels of site contaminants are present and dissolved solids content is also high (over 10,000 ppm). The water is largely a sodium sulfate water with significant levels of carbonate and bicarbonate. There are limited oxidation reduction data for the water in the piles, but limited data suggests the conditions are somewhat reducing with recent oxidation-reduction potentials of -10 to -570 mV.

1.4.4 *Extraction and Injection Systems*. Ground water remediation and contaminant plume control has been underway since the late 1970s at the site. The current extraction and injection program is highly complex and not well documented. Ground water is currently extracted from the alluvial aquifer downgradient of the southwest corner of the large tailing pile, under the small tailings pile, upgradient of the large tailing pile, and approximately ½ mile south-southeast of the small tailings pile. Additional extraction takes place seasonally in the downgradient ends of the two uranium plumes and this water is used for irrigation of crops on land owned by Homestake. The water used for irrigation is contaminated by uranium and other site contaminants and is applied without treatment. Accumulation of uranium in the soil of the irrigated acres is routinely monitored. Extraction of water from the Upper Chinle aquifer is conducted south of the large tailing pile and from the Middle Chinle aquifer north of the large tailing pile. Additional extraction occurs within and just below the large tailings pile.

Injection of water occurs in conjunction with the extraction downgradient of the large and small tailings piles, and ½ mile south-southeast of the small tailings pile. Injection of water also occurs near the downgradient portions of the uranium and selenium plumes downgradient of the site and into the Upper and Middle Chinle aquifers. Water is also injected into the large tailings pile. Most of the water that is injected around the site is clean water pumped from the San Andres formation. Total injection flows into the alluvial aquifer are generally much higher than the total extraction rates.

1.4.5. *Treatment System*. The treatment plant treats some of the water extracted from the alluvial aquifer and some of the water extracted from the large tailings pile. Treatment consists of a clarifier (with lime addition), filtration primarily via sand filters, and reverse osmosis (RO). The RO system includes both high and low-pressure units. Brine from the RO system and some water extracted from the tailings are directly disposed of in the on-site evaporation ponds. Solids from the clarifier and filtration system also go to on-site ponds. The treatment capacity is nominally 600 gpm, but practical limitations are less than that, particularly due to operation of the clarifier.

1.4.6. *Evaporation Ponds*. Wastes from the treatment plant and some solutions extracted from the large tailings pile are discharged to on-site single-lined ponds for evaporation and concentration of salts. The easternmost evaporation pond (#1) is single lined and constructed on a portion of the top of the small tailings pile. Evaporation pond #2 is located just west of Evaporation Pond #1 and is double lined. Two smaller collection ponds are located west of Evaporation Pond #2. Sprayers are installed in the two evaporation ponds to increase evaporative loss of water. Spraying is done seasonally and only during times of low wind velocities. Evaporative capacity is reportedly a limiting factor under the current remediation strategy and a new lined pond of 30 acres surface area was approved by the NRC and NMED and is currently being constructed west-northwest of the large tailings pile. At the time of completion of the ground water remedy, the ponds would be covered and capped along with the tailing piles.

2 CONCEPTUAL SITE MODEL

2.1 Sources. The primary potential sources of contaminants at the site include the two tailings piles and the former mill building site. The evaporation ponds and irrigated acreage may represent secondary sources.

2.1.1 *Conditions in the Tailings Piles*. The conditions in the tailings piles reflect the chemistry used in the milling process. A significant mass of uranium is still present in the tailings. Reportedly, the uranium ore processed at the site had 0.04 to 0.3% U3O8 content (Skiff and Turner, 1981). Assuming the ore had an average of 0.15% uranium content and that the tailings had an average of 0.006% remaining uranium (based on information in EPA 402-R-08-005, Table 3.13), the 22,000,000 tons of tailings would contain approximately 2.6 million pounds of uranium, or approximately 2.5 times the amount estimated to have been removed during the cleanup effort through 2008. The redox (generally negative) and pH (near 10) conditions suggest the uranium in the piles would be in the +6 state and mobile, but slight reductions in pH could result in some reduction of the mobility of the uranium. Given that the uranium remaining the piles represent what could not be fully extracted from the ore, it is possible the uranium is not as accessible for dissolution, but it may slowly mobilize over time. It is possible that without significant changes in the pore water chemistry, or the reduction of driving head and infiltration through the pile, uranium mass could continue to leach into the underlying native materials. The approach taken by Homestake assumes the uranium in the pore fluid is mobile, but other uranium mass in the solids is immobile; however, there are many pore spaces that contain fluid that are not significantly participating in the flow if in fine-grained material or in dead-end pores. Based on a description of the tailings discharge process provided by Homestake Mining, the conditions in the tailings pile are likely heterogeneous with significant lateral and vertical variation in hydraulic properties such that flow is far from uniform through the pile materials. The fluids in less mobile zones may still diffuse out into the more permeable pathways during and after injection.

2.1.2 *Mill Site*. Though not specifically addressed in many of the available reports, there is some suggestion in ground water monitoring data that the location of the former mill buildings east of the large tailings pile was or is a source of contamination to the ground water. Elevated uranium levels (up to over 40 mg/L in 2003) in some of the "1" series wells have been observed there. The nature of the source is not clear.

2.1.3 *Evaporation Ponds*. The evaporation and collection ponds have essentially been concentrating site contaminants, including uranium. Though there is no evidence of leakage, the ponds could be a secondary source of contaminants affecting air, soil, and ground water if the liners under the ponds were to leak, or if the ponds become a source of radon or dust.

2.1.4 *Irrigated Acreage*. Application of uranium- and selenium-contaminated ground water to irrigated land results in the accumulation of these elements in the soils. These soils can then release contaminants into dust or to deeper soils and possibly ground water through leaching processes. There is no evidence for impacts to ground water at this time and future impacts are uncertain.

2.2 Pathways/Affected Media. The releases of contaminants from the primary and secondary sources described above have either contaminated or may contaminate air, ground water, and soil (there are no persistent surface water bodies in the immediate vicinity of the site other than the evaporation and collection ponds). These media could potentially transport contaminants to humans or ecological receptors.

2.2.1 *Air*. Potential impacts to humans can occur through outdoor air or indoor air. Particulate matter can be transported by winds away from the sources. Radon can also be transported via air away from the sources. The air monitoring program at the Homestake site attempts to quantify this pathway. Radon gas can migrate into homes and other occupied buildings.

2.2.2 *Soil*. Though the interim covers on the tailings piles can prevent direct exposure to source contamination, surficial soils around the site could be affected by deposition of airborne particulates or application of contaminated ground water, such as at the irrigated acreage. Deeper native soils could be (and have been) contaminated by leaching of contaminants from sources such as the tailings piles. Any leakage from the ponds could also contaminate deeper soils.

2.2.3. *Groundwater*. The ground water can and has transported site contaminants away from the tailings piles and possibly from other sources at the site. The ground water is also a medium that has been used by residents downgradient of the site. Alternative water sources have been developed for the majority of affected downgradient residents, however, there are still some private wells in use in the downgradient areas.

2.3 Receptors. The primary receptors at the site are the residents in the nearby subdivisions, workers at the Homestake site, commercial workers in the vicinity, visitors, and trespassers. Figure 2 summarizes the conceptual site model.

Figure 1a. Site Location

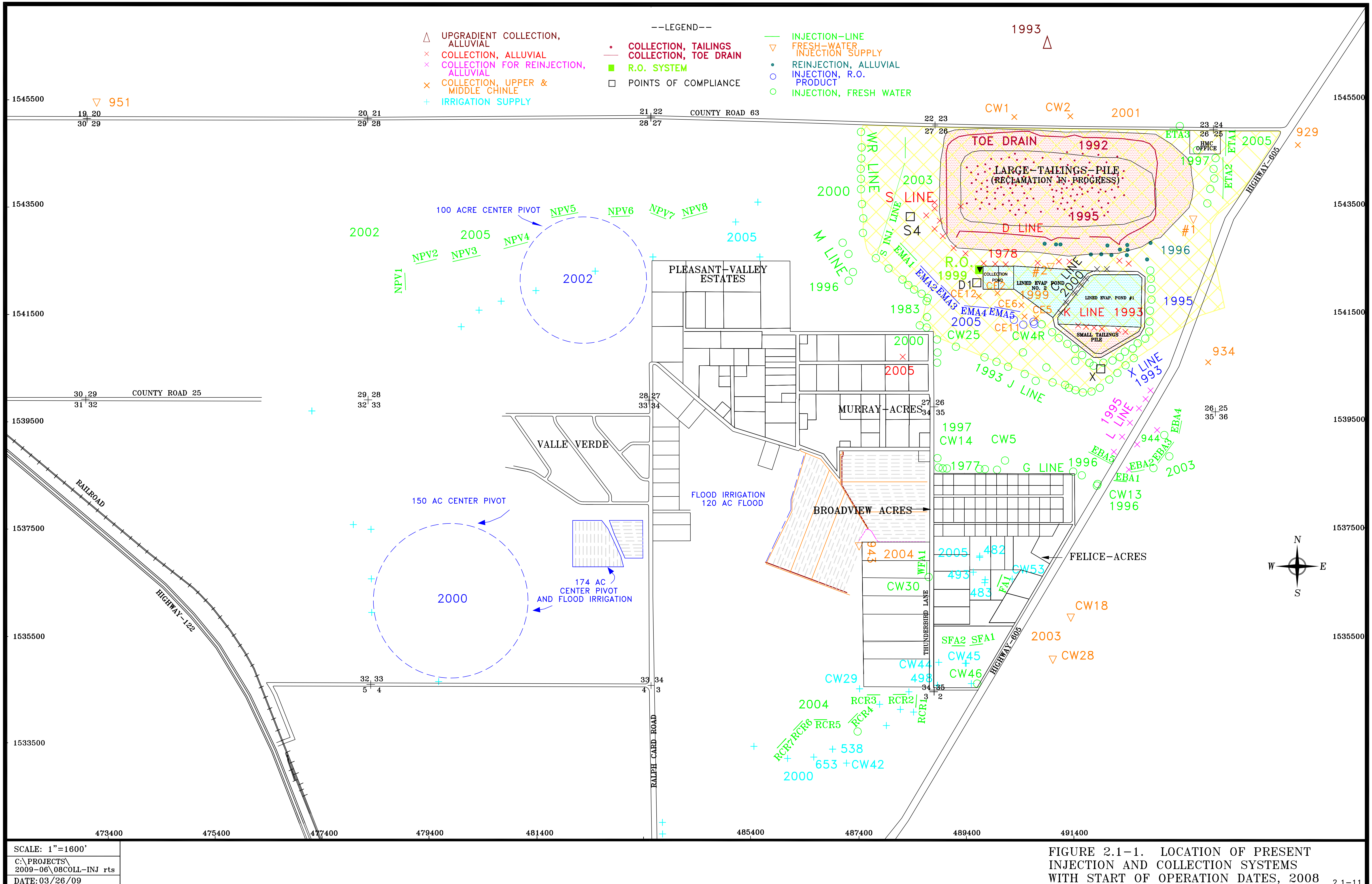


Figure 1b. Well Locations

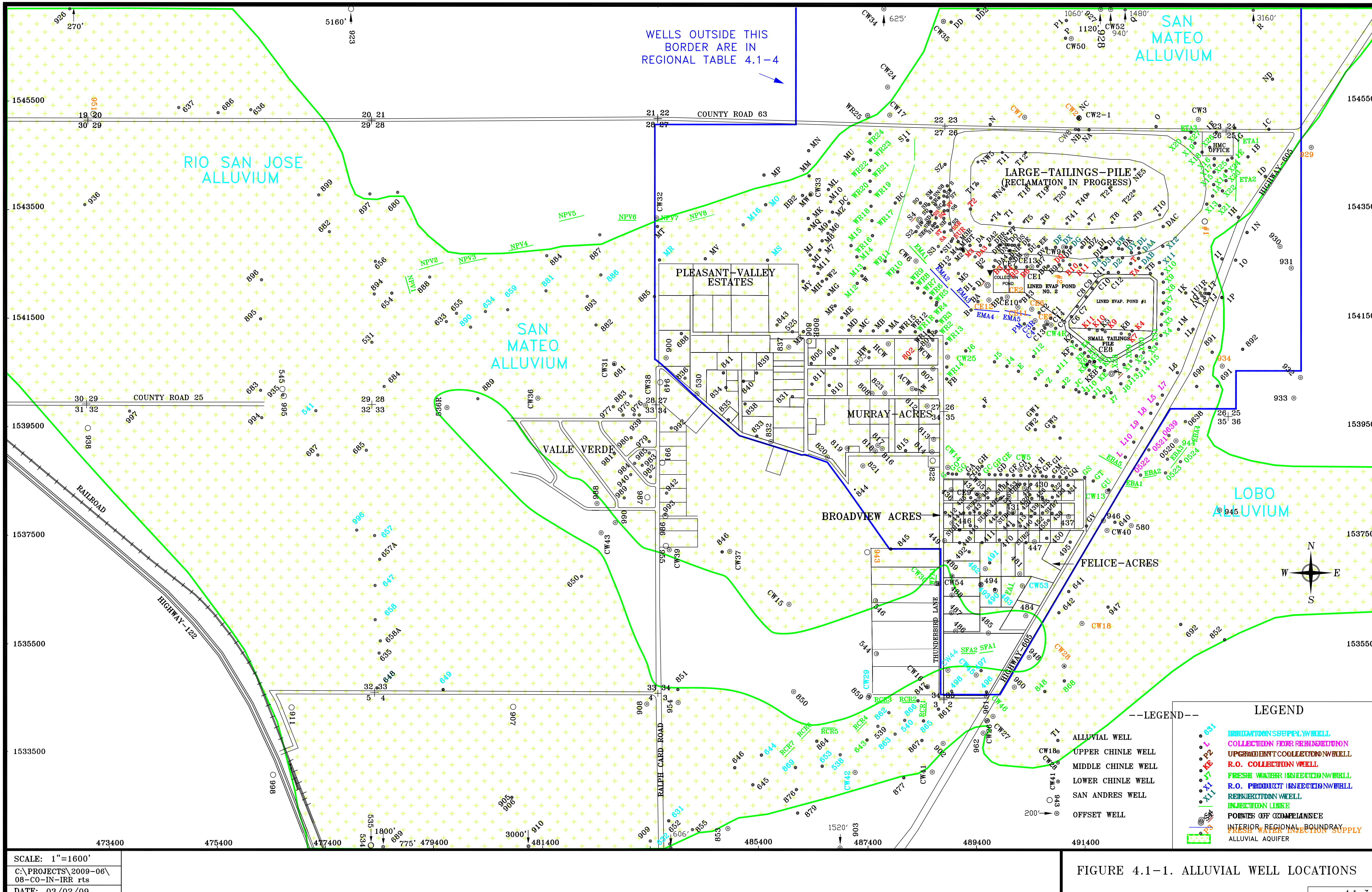
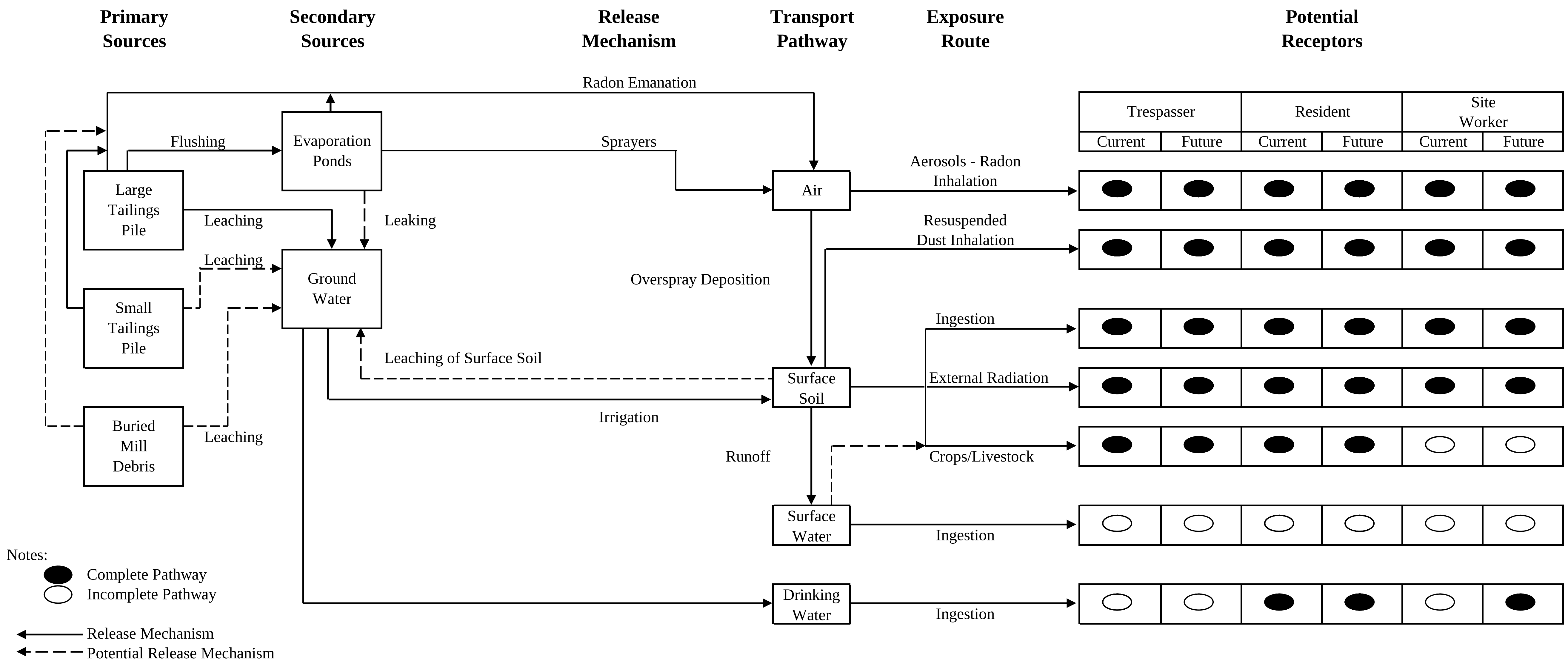


Figure 2. Conceptual Site Model (CSM) Summary

Homestake Mining Company (Grants) Superfund Site



3 ADEQUACY OF PLUME CONTROL

3.1 Hydraulic Capture. The performance of the ground water extraction and injection system in the alluvial aquifer was evaluated by the assessment of ground water levels, concentration trends, and estimates of ground water flux. Hydraulic capture of the contaminant plumes in the alluvial aquifer was evaluated by independently plotting and hand-contouring water levels measured in March-April and June-July 2009. These contours suggest a significant capture of water emanating from the large tailings pile, particularly in the deeper incised alluvial channel along the southwestern end of the large tailings pile. Capture is not as obvious in the contours near the small tailings pile in the March-April contours. The contouring is somewhat limited by the available water levels as only a limited subset of wells appear to be measured. Based on the drawn contours, uncaptured flow lines may bypass injection and extraction at the northwest corner of the large tailings pile.

Capture is not apparent for the irrigation pumping in the downgradient portions of the uranium and selenium plumes, nor is it clear from available data that capture of the plume along Highway 605 east of the site is maintained.

3.2 Concentration Trends. Concentration trends were independently plotted and assessed as an indication of contaminant migration and progress toward clean-up. Ground water concentrations of uranium and selenium in the alluvial aquifer in the vicinity of the small tailings pile have been significantly reduced (such as well X, a compliance point), though some wells have persistent concentrations well above the cleanup goals as represented by the plot of uranium for well K4. Some wells that have shown declines may be impacted by nearby injection of relatively clean water, including well X. This would make it difficult for this well to detect leakage from the ponds.

Figure 3. Well X Uranium Concentration Trends.

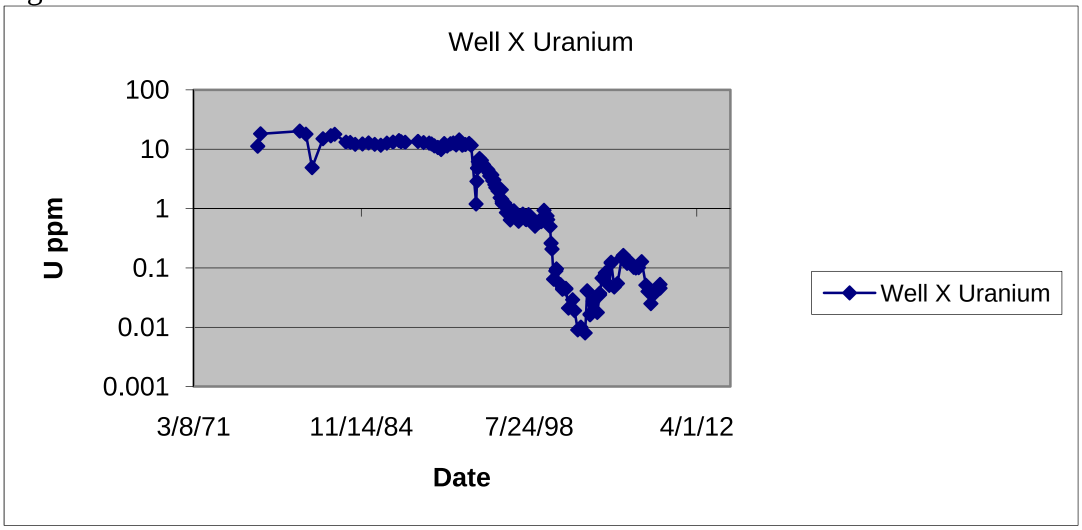
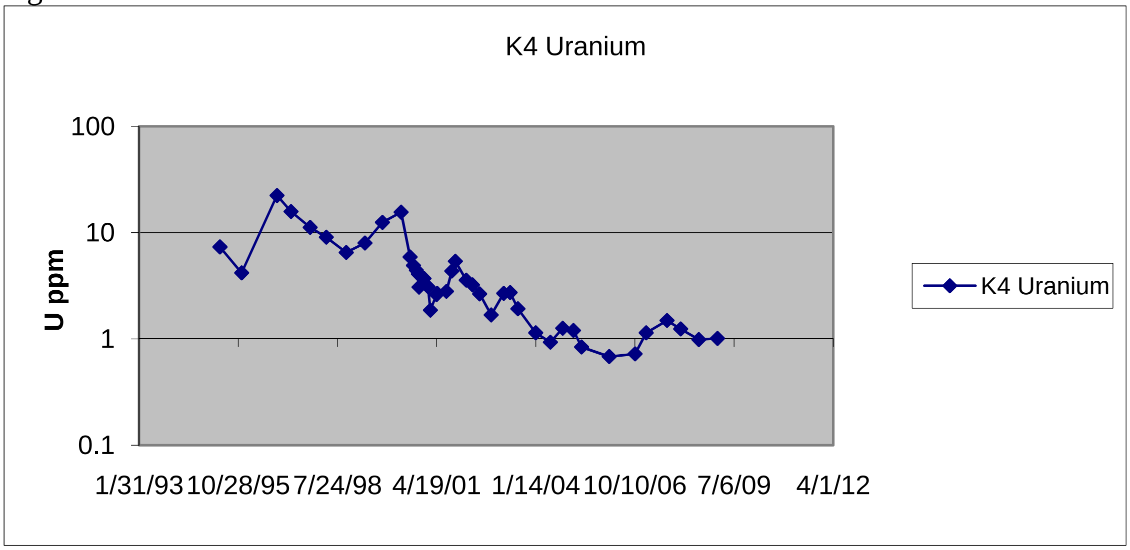


Figure 4. Well K4 Uranium Concentration Trends.



Concentrations in the alluvial aquifer near the southwestern edge of the large tailings pile have also been reduced, such as at well ST, but some remain high, such as at well S2, located downgradient of the extraction system, and at others, such as B4 between the pile and the extraction wells, uranium concentrations have actually risen.

Well S11 is screened in the alluvial aquifer near the northwest corner of the large tailings pile along the suspected flow path possibly outside the capture of the extraction and injection system. This well shows an erratic but generally higher trend in uranium and sulfate concentrations after 2004. It is not clear if the variability in concentration is related to changes in the operation of the injection laterals in this area.

Figure 5. Well ST Uranium Concentration Trends.

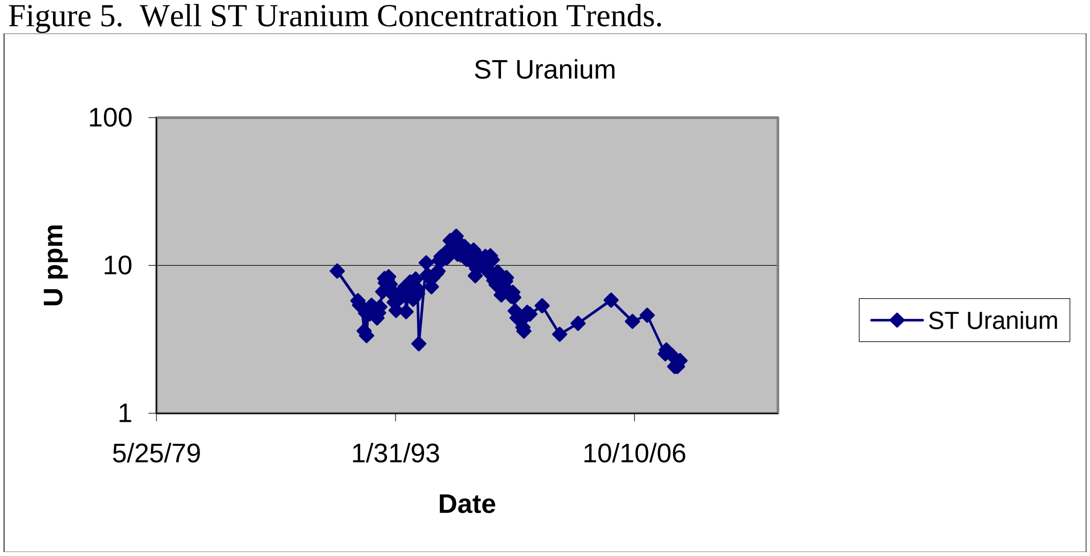


Figure 6. Well S2 Uranium Concentration Trends.

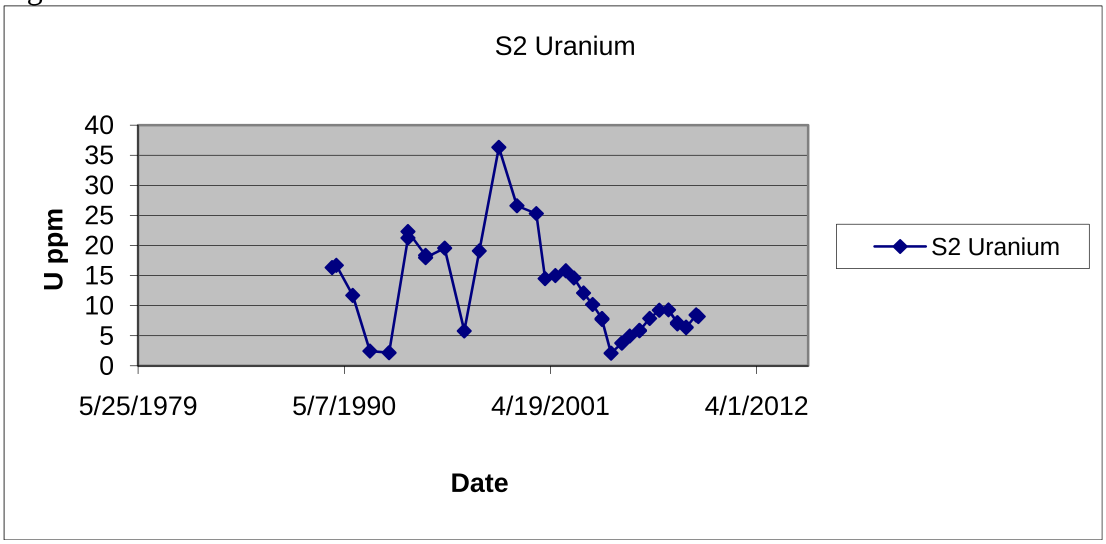


Figure 7. Well B4 Uranium Concentration Trends.

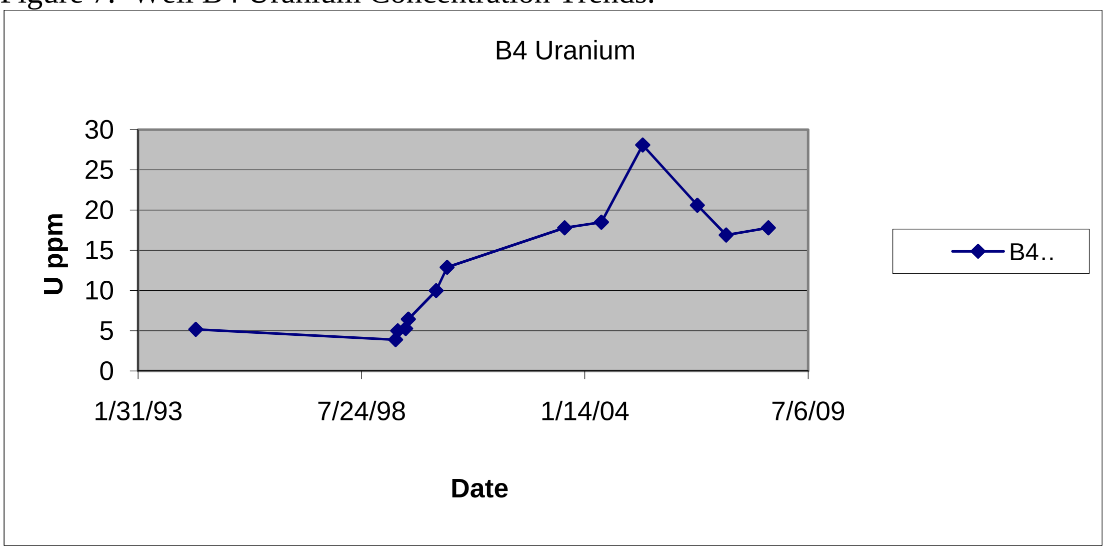


Figure 8. Well S11 Uranium Concentration Trends.

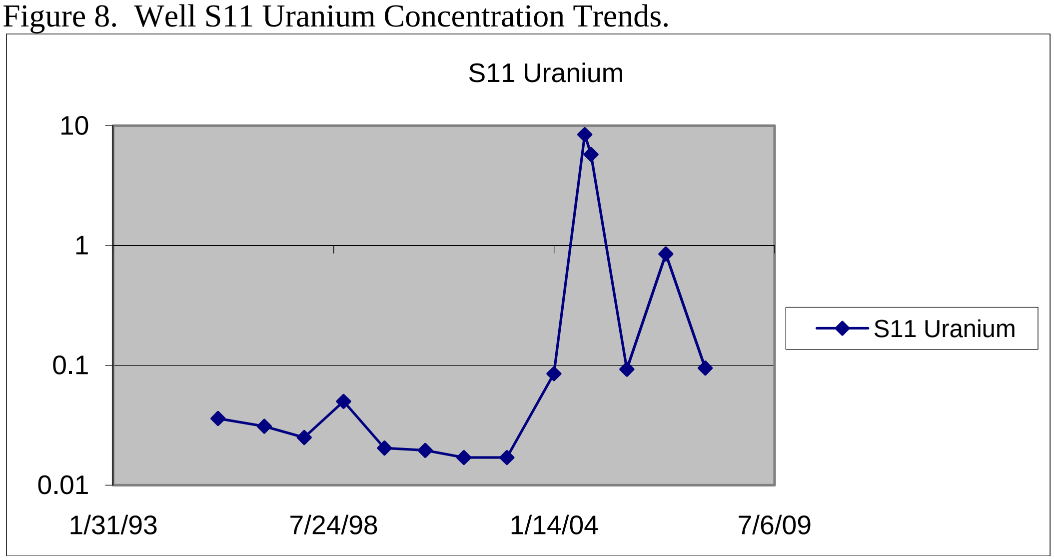
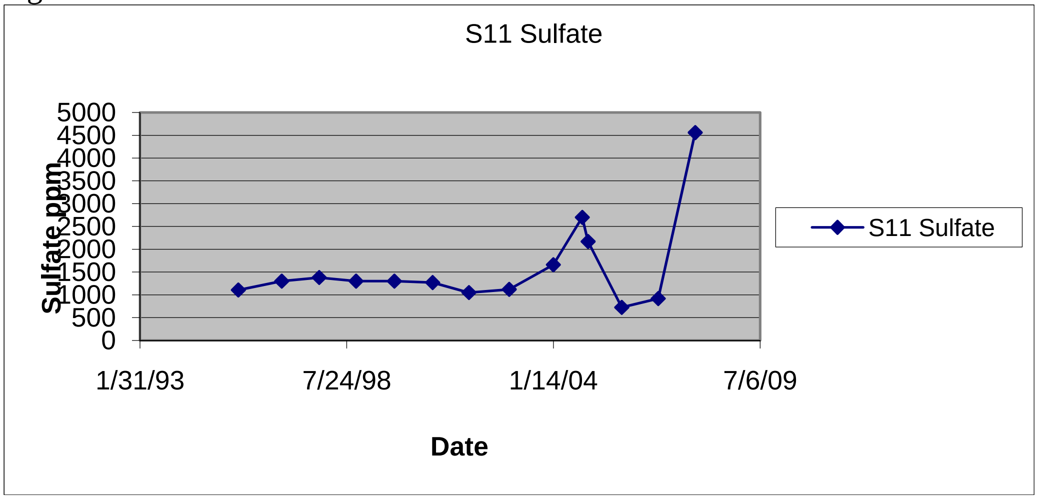


Figure 9. Well S11 Sulfate Concentration Trends.



The concentrations in the downgradient portions of the uranium and selenium plumes have generally been reduced (e.g., Wells 0654 and 0864, downgradient of the irrigation pumping used to capture the plume), but well 0882, located south of the wells used for irrigation in the northern plume, has shown an increase in concentration. This suggests that the capture may not be complete.

Figure 10. Well 0654 Uranium Concentration Trends.

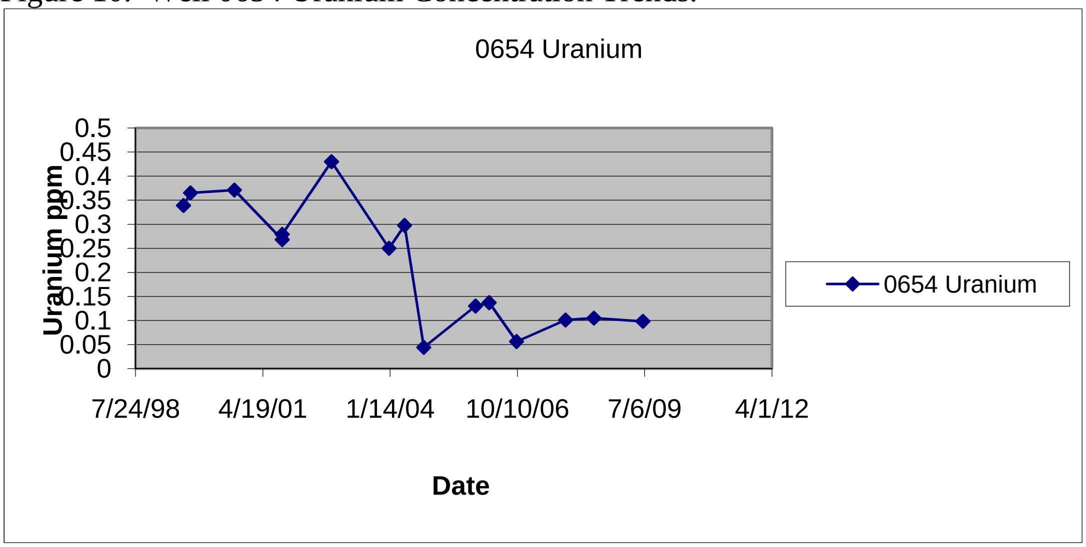


Figure 11. Well 0864 Uranium Concentration Trends.

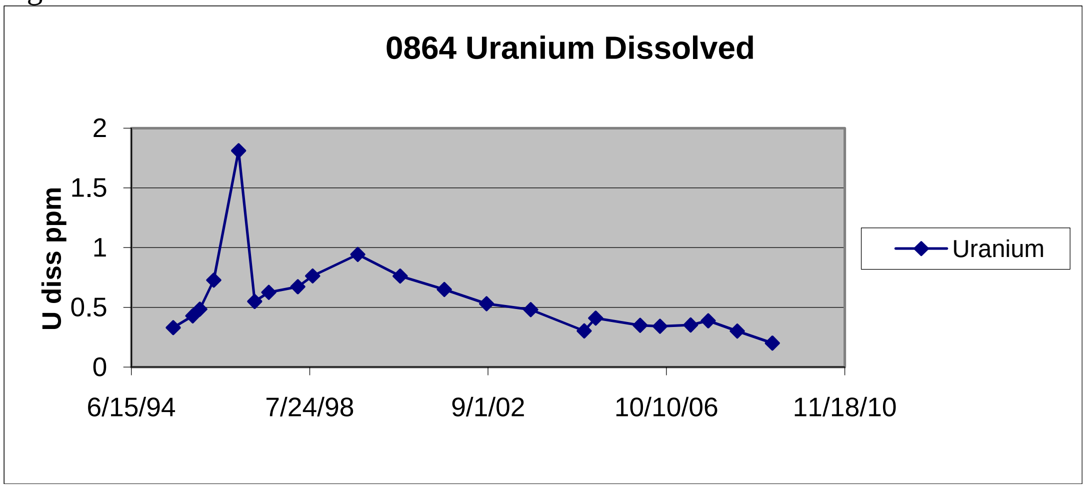
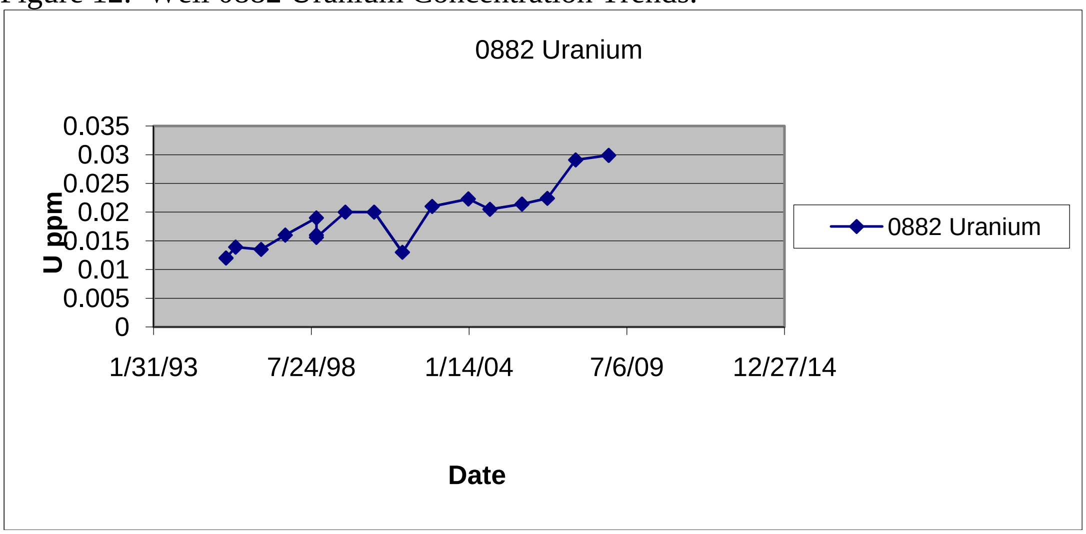
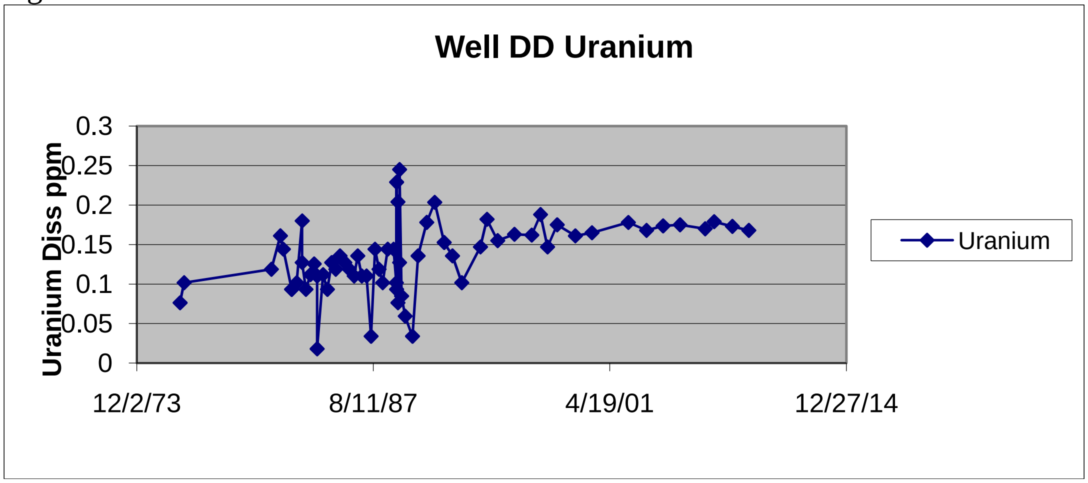


Figure 12. Well 0882 Uranium Concentration Trends.



The evaluation also included a survey of background ground water quality upgradient of the large tailings pile. Though some of the far upgradient wells do show significant impacts from uranium, upgradient wells closer to the site have shown only more subtle increases, including wells P1, P2, and DD (shown for illustration). Higher concentrations (above the 0.160 alluvial standard) appear to be found in wells on the western edge of the San Mateo alluvial valley, including well DD. These may be related to the increasing trend in uranium concentrations in well S11 downgradient and apparently along a flow path from well DD. This illustrated the need to consider background concentrations of uranium in assessing site strategies for the alluvial aquifer.

Figure 13. Well DD Uranium Concentration Trends.



3.3 **Groundwater Flux**. There are concerns regarding the performance of the alluvial ground water extraction and injection system arising from the assessment of the mass flux through the system. The introduction of substantial amounts of water from deeper aquifers into the alluvial aquifer suggests that, to some degree, concentration declines may be due to dilution, rather than removal of contaminant mass. The substantial addition of water in the vicinity of the tailings piles and difficulty in assessing where the water is exactly being added makes the determination of the capture of the flux of alluvial aquifer water flowing under the piles uncertain. As stated above, displacement of some of the contaminated alluvial ground water flow to the west and, to a lesser extent, east of the piles is possible.

3.4 **Ground-Water Modeling**. The report (Hydro-Engineering, 2006) on the development of the current ground water flow and transport model was qualitatively reviewed, with the intent of assessing the use of the model as a predictive tool and a means to further verify extraction and injection system performance. Though there was limited information on calibration statistics and the residuals at individual calibration targets, the report does present comparisons of observed and predicted piezometric contours and contaminant concentrations. There seemed to be reasonable agreement between the observed and simulated values. It appears that the flow (MODFLOW) and ground water transport (MT3DMS) modeling was conducted in accordance with normal industry practice.

The primary concern with the modeling conducted for the site is the simulation of the seepage of contaminated water from the large tailings pile. From the available information on this step in the modeling process, it appears the modeling did not account for the heterogeneity and preferred pathways for water injected into the tailings. It is very probable that the flux of water is not uniform through the pile and that large volumes of the pile still have a significant amount of their original pore fluids. The model likely over-predicts the performance of tailings flushing.

3.5 Chinle Aquifer Contaminant Control. The performance of the extraction and injection system to address the contamination in the Chinle aquifers was assessed by the qualitative review of the information presented in the 2008 Annual Report for the site. Performance for the extraction system in the Upper Chinle aquifer appears to be adequate for containing the predominant contaminants. The ground water conditions in the Middle Chinle aquifer are problematic. The ground water elevations are spatially quite variable and do not make hydrologic sense. Based on the observed contours (October, 2008), it is not clear that uranium in this aquifer is being adequately controlled by pumping from the Middle Chinle.

3.6 Impacts to the San Andres Aquifer. A review of water quality data and water levels for the relatively few wells screened in the San Andres Formation was conducted. Though few data were available, there was no evidence of contaminant impacts to these wells. Water levels were reasonably consistent and indicated a ground water flow direction in the San Andres toward the northeast in March 2009. Flow directions observed in 2008 and reported in the 2008 Annual Report were more easterly to east-southeasterly. The well replaced by well 0806R should be properly decommissioned in accordance with State requirements as soon as possible if not already completed.

4 OVERALL REMEDIAL STRATEGY

The overall remedial strategy being implemented by Homestake is to flush the highly contaminated pore fluids from the large tailings pile (to concentrations less than 2 ppm uranium) and to capture the seepage and contaminated alluvial aquifer ground water near the southern edge of the tailings piles. The extraction is coupled with downgradient injection of water to assist in creating a hydraulic barrier. Subsidiary extraction and injection occurs along State Highway 605 and in the downgradient portions of the northern and southern alluvial ground water plumes. Additional extraction and injection occurs in the Chinle aquifers to control the plumes and to restore aquifer quality. According to Homestake, flushing of the tailings pile will be completed by 2012, with the remediation of the ground water contamination completed by 2017.

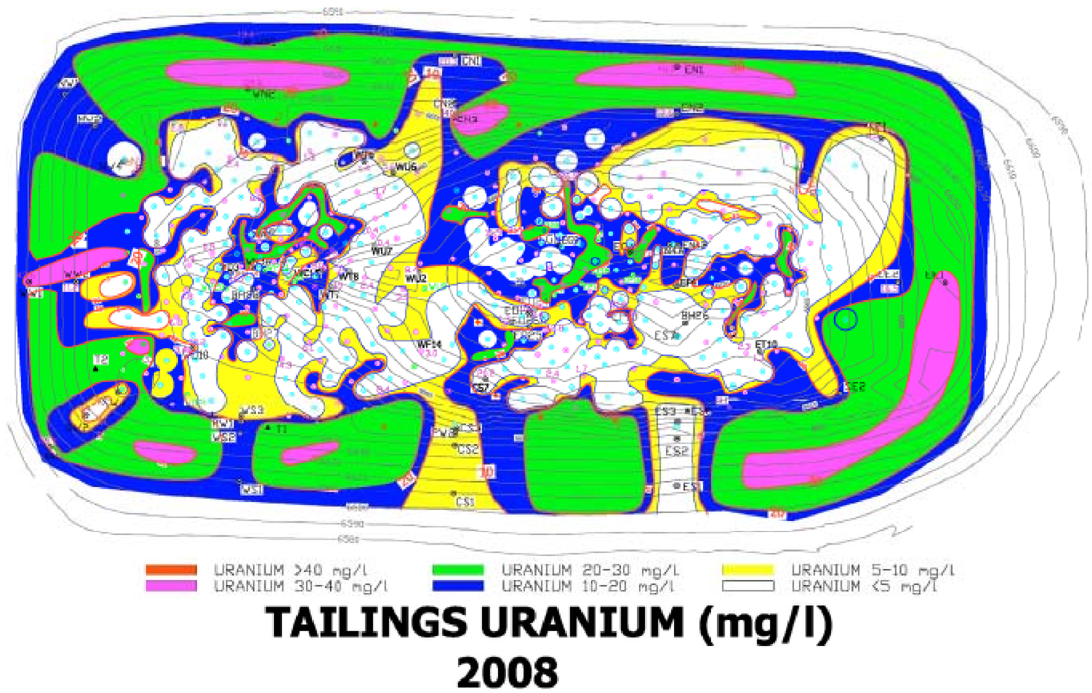
This strategy has been evaluated regarding the likelihood of attaining its milestones by the planned dates, the adequacy of the protection of human health and the environment, and the cost-effectiveness of the work. The current strategy is generally overly complex and at least partially depends on dilution to attain its goals. Alternatives to the current strategy are broadly described and potentially applicable replacement technologies are discussed below.

4.1 Flushing of Large Tailings Pile. The flushing of the large tailings pile with fresh water largely derived from the Chinle aquifers is unlikely to truly achieve its objective. Though the average concentration in recovered water from the toe drains and sumps, and concentrations in wells penetrating the tailings has declined significantly, the heterogeneity of the materials has prevented uniform flushing of the pore fluids. The highly variable concentrations observed over relatively short distances in the tailings would argue for such heterogeneity (as shown in Figure 14). Furthermore, the nature of the wells in the tailings complicates the interpretation of the results. Most of the wells that have been sampled have long screened intervals (most over 70 feet) and the wells extend to depths below the tailings themselves. The likely occurrence of vertical movement in the well from one permeable zone in the tailings to another, particularly if injection was conducted in it at some point, makes it difficult to assess how representative the samples are.

A review of the concentration trends for wells penetrating the tailings with reasonably complete sampling histories was conducted. Though concentrations have generally declined in the pile, a significant number of wells remain at high concentrations of uranium without evidence of further declines. For example, concentrations in wells WC1, WN4, EN4B dropped dramatically at the start of injection, but have not significantly and consistently declined further as shown on the Figure 15.

It is probable the flushing program would not meet its goal by 2012, and in fact, the need for ground water control would probably extend for many years past that date under any scenario. Furthermore, the potential for rebound in concentrations once flushing would cease should also be considered. In fact, it may be prudent to conduct a pilot test in a portion of the tailings pile in the next few years to assess rebound potential. Even if goals were to appear to be achieved, given the incomplete contact between injected water and all tailings, and given the geochemical conditions that may allow slow leaching of additional uranium out of the tailings solids, additional mass of uranium would ultimately be available for leaching from the pile, contrary to the anticipated conditions under the current strategy.

Figure 14. Uranium Concentrations in Large Tailings Pile

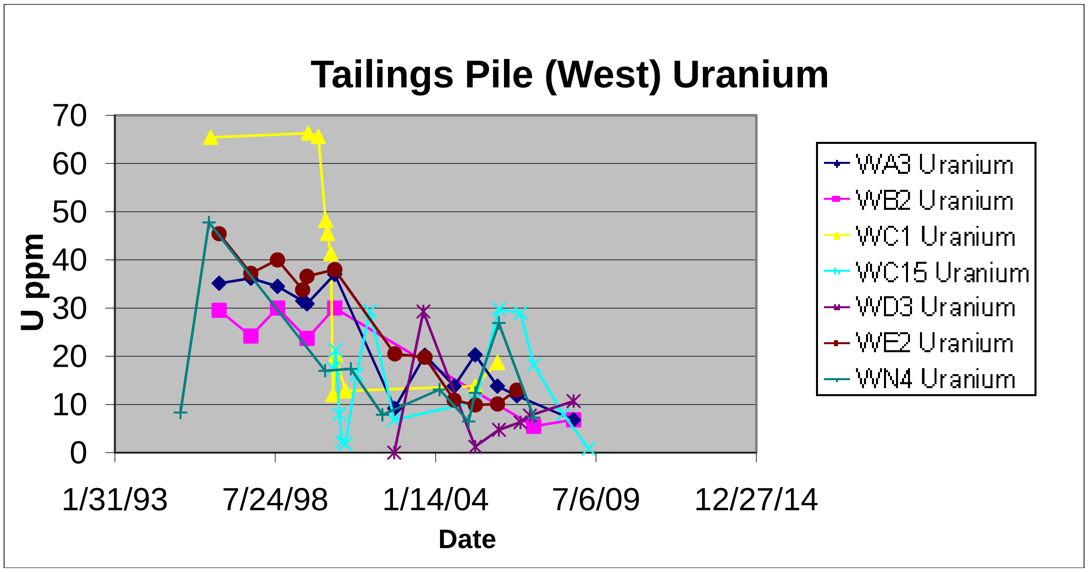


It is noted that as part of the current flushing program that the slimes present in the LTP have apparently resulted in the flushing water becoming more reducing from the organic matter in the slime. The data collected by HMC indicates that the selenium concentrations have decreased significantly in the groundwater beneath the LTP (Homestake 2009), presumably because of the more reduced geochemistry leading to precipitation of selenium. There is the potential that if the flushing of the LTP was stopped, the migration of groundwater through the LTP could gradually reoxidize the groundwater and dissolution of the precipitated selenium and uranium could occur (Wellman 2007).

Additional testing of oxidation-reduction potential would facilitate the analysis of the fate and transport of the remaining contaminants in the pile. Such testing would entail measurements of ORP, with pH, dissolved oxygen, and conductivity, downhole in wells that have not been used recently for flushing. The data would be used to evaluate, through geochemical modeling or comparison to appropriate Eh-pH diagrams, the stability of uranium and selenium remaining in the pile, both where flushing occurred and where there is little evidence of flushing influence.

The water recovered from the sumps around the tailings piles do not show dramatic declines in uranium concentrations. Most have relatively stable or slightly decreasing trends, though the N3 Sump has displayed a four-fold increase in a relatively short time. These results suggest the flushing has had a limited effect in at least parts of the pile. Representative concentration histories are provided in Figure 16.

Figure 15. Uranium Concentrations in Select Wells in a) Western Large Tailings Pile and b) Eastern Large Tailings Pile.



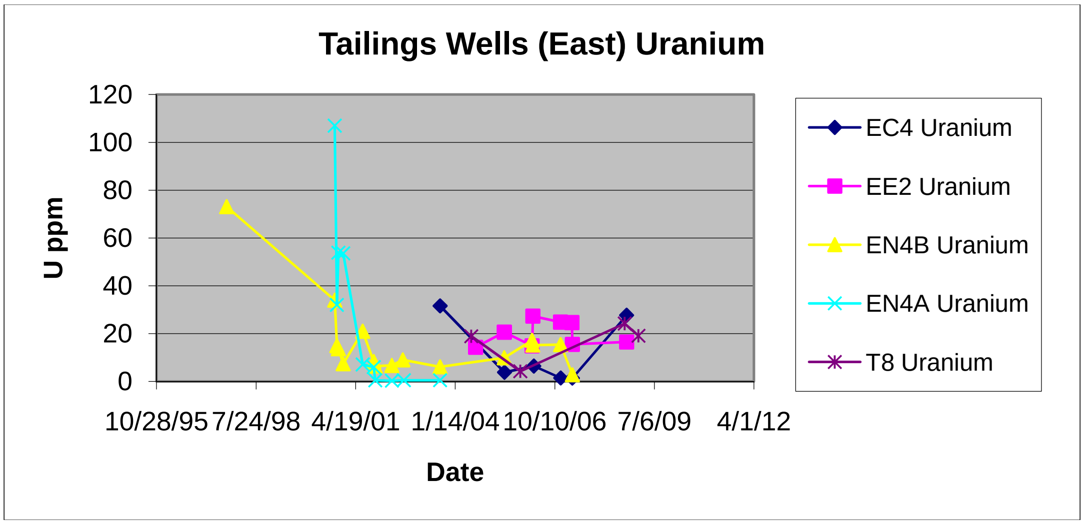
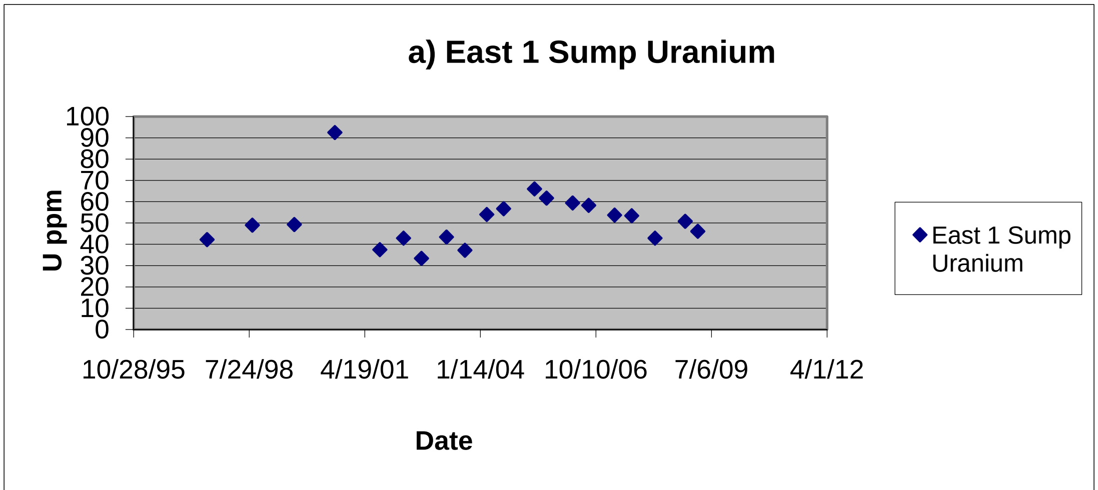
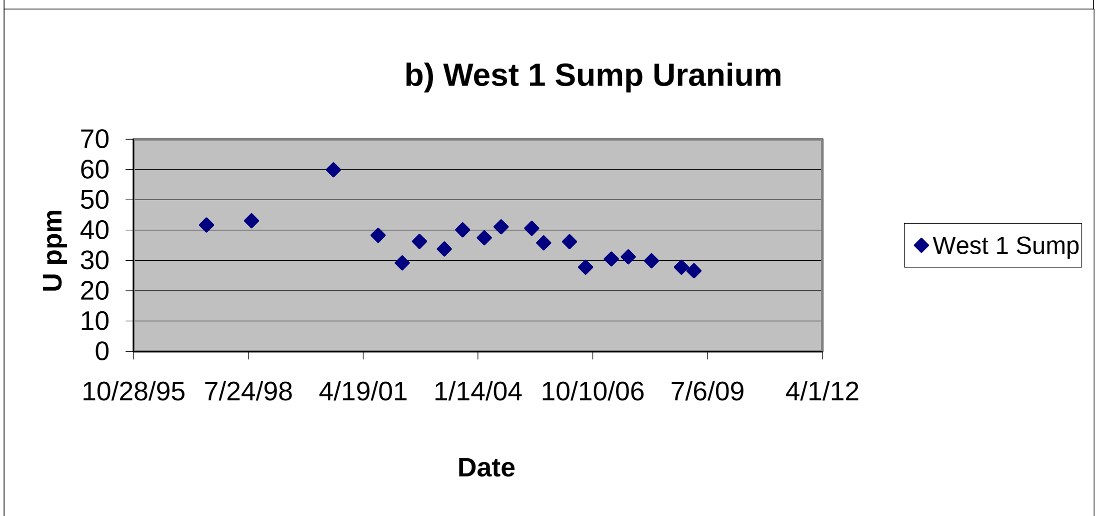
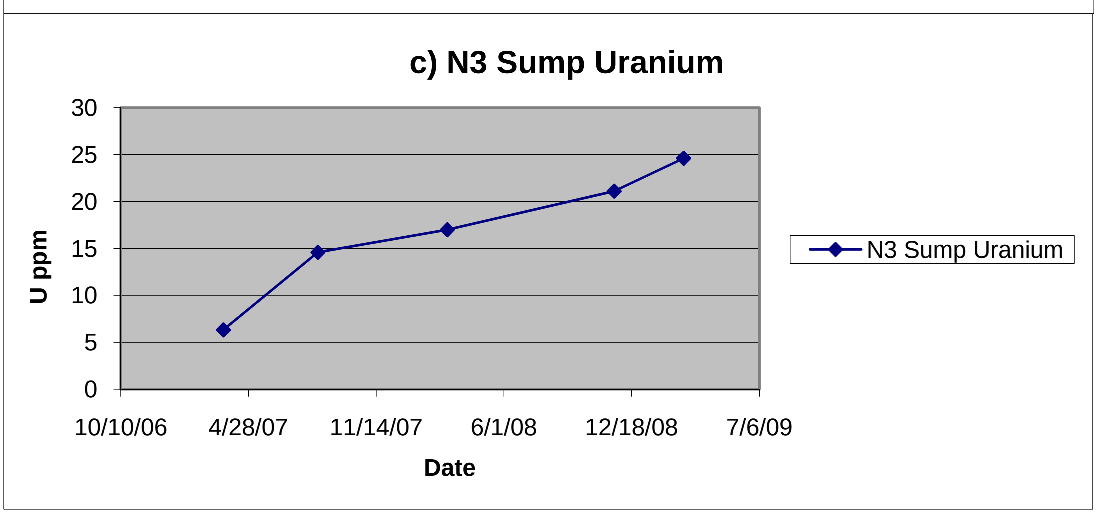


Figure 16. Uranium Concentrations in Select Sumps: a) East 1 Sump, b) West 1 Sump, and c) N3 Sump







As another line of evidence, the total volume of injected water was compared to an estimate of the total pore space in the large tailings pile. Assuming approximately 200 gpm of clean water was injected into the pile for the 8 years since 2001 (up to the most recent sampling data), approximately 840,000,000 gallons, or 110,000,000 cu ft, of water have been introduced. Assuming a tailings volume of 800,000,000 cu ft and a porosity of 30%, there is about 240,000,000 cu ft of pore space. Based on this, assuming perfectly uniform flushing by injected water (unlikely), only about half of the water that would have been present has been flushed. Note that this doesn't account for the volume of contaminated soils below the tailings but within the screened intervals of the wells, or the increase in water storage in the pile since flushing began.

Finally, the addition of such a large quantity of water into the tailings increases the amount of water that must be recovered from the alluvial aquifer and treated and/or evaporated. If the injection was to stop, and seepage was allowed to occur from the tailings, the flow of tailings water into the alluvial aquifer would slow significantly with time. This would reduce the pumping needed to capture water to a rate that essentially matches only what was naturally flowing under the tailings and whatever seepage was occurring. Assuming a reasonably conservative hydraulic conductivity of 80 ft/day, a natural gradient in the alluvial aquifer of 0.008, a width of 4500 feet and an average saturated thickness of approximately 30 feet (with variations from 0 to over 50 feet), a natural flow of 86,000 cu ft/day or about 450 gpm or less would have to be captured. In addition, the seepage from the tailings would also have to be captured. Though initially the flow would be relatively high, it would decline over time as the head in the pile would drop. Note that the drainage of the tailings may take decades. The concentrations of liquids recovered from the tailings may increase following cessation of flushing. Though some of the recovered liquids would be best discharged directly into the evaporation ponds, it is anticipated that a larger proportion of water would be treated by RO than is currently the case, maximizing the capacity of the existing ponds. It is recommended that this simplification to the remedy be implemented.

4.2 Downgradient Extraction and Injection. Though useful for assisting in creating downgradient hydraulic barriers, injection of relatively clean water from other aquifers into the alluvial aquifer downgradient of the site at rates that exceed extraction complicates the control of the plumes and may do more to dilute the plume rather than treat it. It is recommended that extraction be conducted at a rate necessary to capture the three-dimensional extent of the existing plumes. Near the treatment plant, treated water would be available for injection. If used, injection into the alluvial aquifer should be located to minimize recirculation of water to the extraction wells. This treated water would perhaps be best used to reverse the hydraulic gradient from the alluvial aquifer toward the Upper Chinle aquifer by injection into the Upper Chinle. Current practice of extraction from the Upper Chinle draws water downward from the more contaminated alluvial aquifer, perpetuating the need for pumping. Though injection into the Chinle is currently done, the injection could be increased in a step-wise fashion driving the contaminants back toward the subcrops of the Upper Chinle at the base of the alluvial aquifer. Care would have to be taken to prevent spread of contamination in the Upper Chinle. Additional monitoring points may be needed and vigilant monitoring during the implementation of the injection will be required.

Pumping of water from the northern and southern downgradient uranium and selenium plumes would continue, but without injection of water from other aquifers into the alluvial aquifer. The water pumped from these portions of the alluvial aquifer would either be used directly for irrigation or treated for irrigation or re-injection (see section 8, below). The extraction would be best done where it is now, at the narrow portions of the saturated incised channels of the alluvial aquifers, near the 0.16 mg/L uranium contour and upgradient of the confluences of the San Mateo alluvium and the Rio San Jose alluvium. Contamination downgradient of these points would be allowed to naturally attenuate due to dispersion and sorption to iron oxyhydroxides and clays. Based on the presumed oxidized condition and low organic carbon content of the alluvial aquifer, other attenuation processes are unlikely to be significant.

The conditions in the Middle Chinle require additional study to assess the circumstances surrounding the unusual water levels in wells in the Middle Chinle and the true ground water flow directions, especially in areas where concentrations exceed clean-up goals. These studies may include examination of hydrographs, verification of top of casing elevations, checking transcription errors, and possibly installing new wells. Extraction of additional water, particularly in the vicinity of the Felice Acres subdivision may be necessary.

4.3 Evaporative Concentration of Salts and Final Entombment of Wastes. The current end point for wastes generated by the ground water extraction system is either evaporative concentration of salts in the on-site ponds, or as accumulated salts in the soils of the irrigated acreage. The use of untreated water for irrigation and the fate of the accumulated contaminants in soils as a result are addressed in section 8. Unless the decision is made to remove all wastes from the site (discussed further in section 4.4 below), the strategy of on-site management is reasonable. The salts accumulating in the evaporation ponds may have some economic value at some time in the future. If not, the dewatering and capping of the ponds at some time in the future would be consistent with the current strategy of managing wastes on-site under the long-term stewardship of the Department of Energy. The combination of a highly effective cap with the existing liner under the pond wastes will provide added assurance of the isolation of the waste.

The integrity of the liner under the collection ponds was assessed through the qualitative analysis of water levels and contaminant concentrations in adjacent alluvial aquifer monitoring wells. The water levels observed in the wells were compared to the variations in water levels in the ponds to glean evidence for leakage. (Note that the post-2006 values in the database for the top of casing elevation for some of the C series wells are apparently in error by almost 100 feet). A signal similar to the seasonal variations in the pond water levels or a long-term rise in water levels following initial use of the ponds in the mid-1990s would suggest possible leakage. The ground water concentrations in the same wells were also analyzed for evidence for increases in solutes or contaminants that would suggest brine leakage from the pond. The analysis was complicated by the significant extraction and injection activities conducted under the ponds. No obvious evidence was found for leaks in the evaporation ponds. Inspection of the liners should continue with emphasis on those sections that are periodically exposed to sunlight.

Additional geophysical monitoring, such as downhole and/or cross-hole electrical conductivity measurement or tomography, could give an indication of the leakage of highly conductive brine.

Figure 17. Water Levels in Evaporation Ponds and Nearby Wells

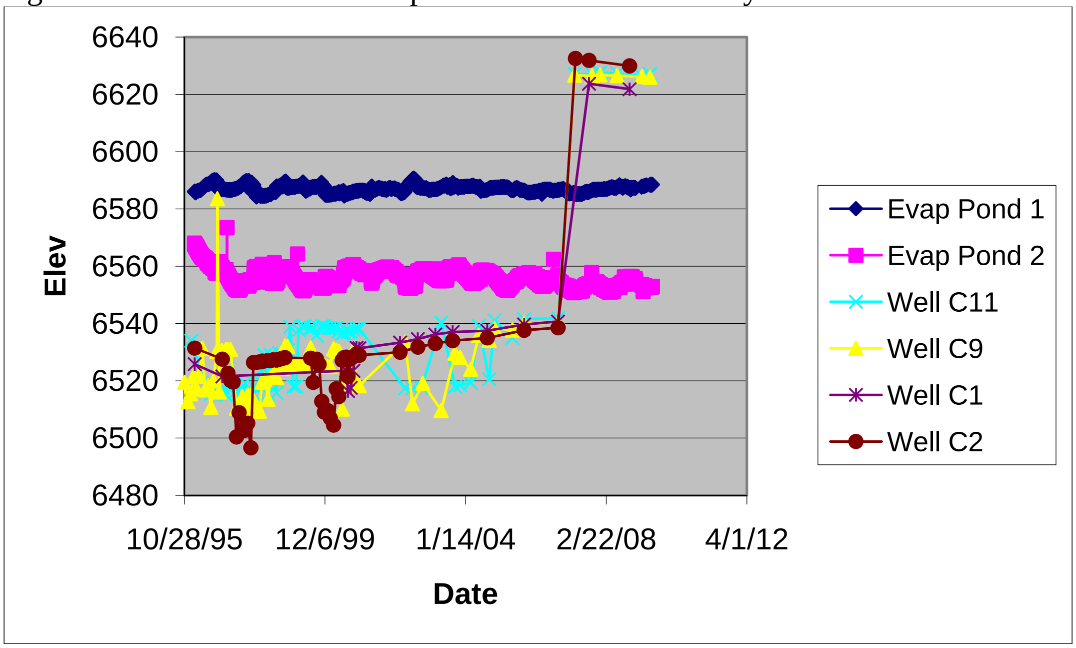


Figure 18. Water Levels in Evaporation Ponds and Other Nearby Wells

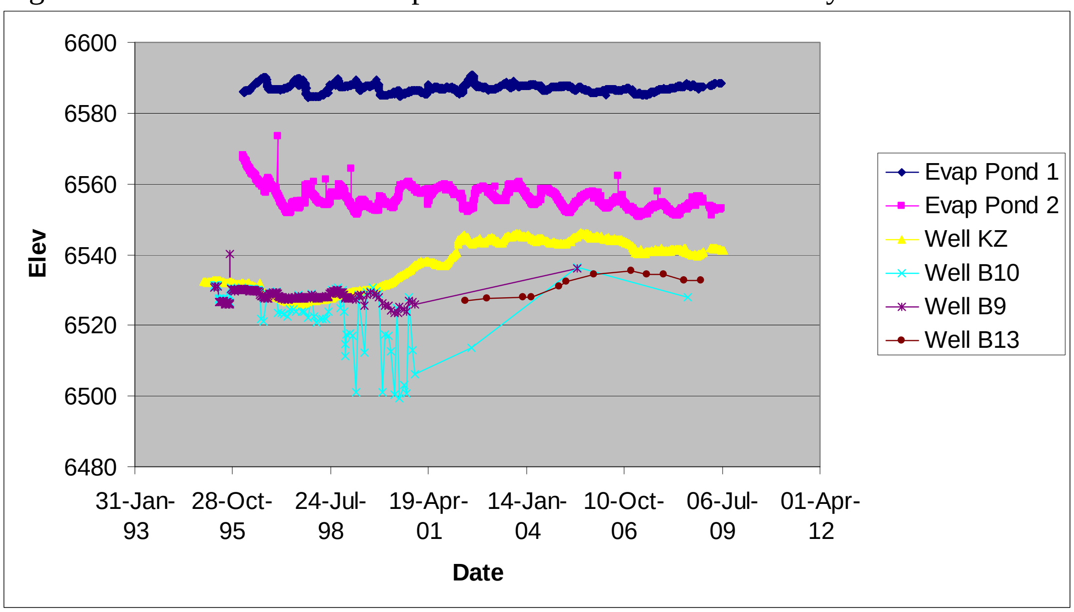


Figure 19. Well K4 Sulfate Concentrations

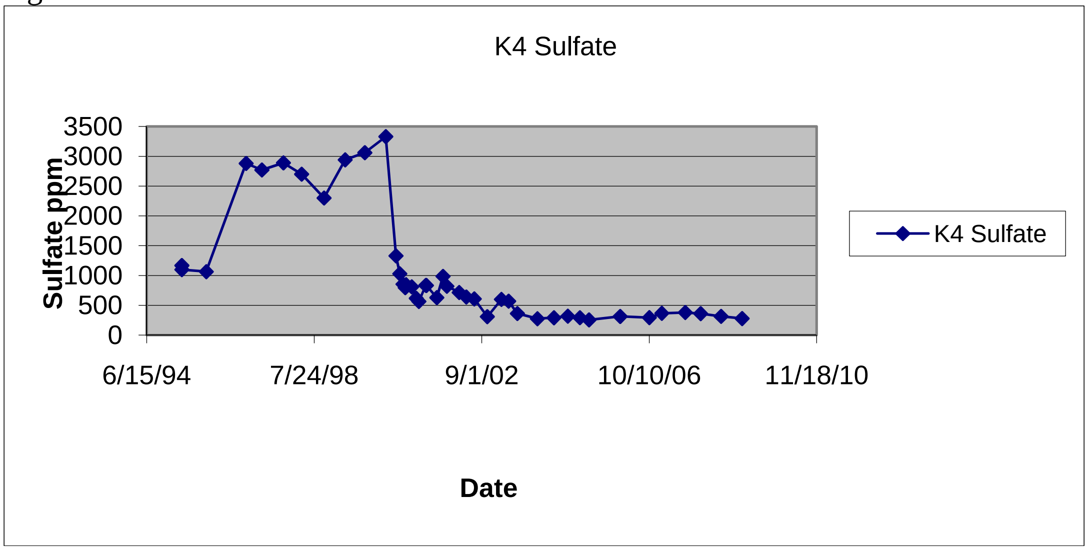
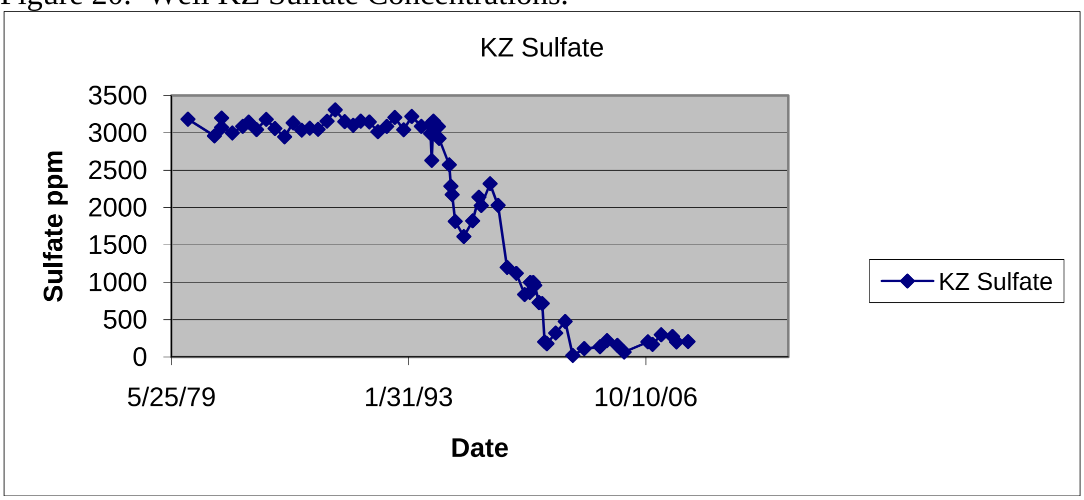


Figure 20. Well KZ Sulfate Concentrations.



4.4 Alternative Strategies. A number of alternatives to the current ground water extraction and injection strategy were considered. These included passive treatment options such as a permeable reactive (zero-valent iron) wall and polyphosphate treatment; isolation technologies including a fully encompassing slurry wall; and full removal of the tailings and placement of the waste in an engineered landfill created for this waste at an unknown location within 30 miles of the site.

4.4.1 *Slurry Wall*. There are a number of sites, both for mine wastes (e.g., a copper mine in Arizona) and for Superfund Sites (e.g., 9th Avenue Dump, Gary IN; Lipari Landfill, Glassboro, NJ) where slurry walls have been used to isolate waste from the surrounding aquifer and environment. A slurry wall around the large tailings pile at the Homestake site would reduce the quantity of ground water requiring extraction and treatment by reducing flux of ground water under the tailings pile. This would potentially reduce the long-term costs for the operations, possibly significantly. The installation of such a slurry wall through the entire alluvial aquifer is technically implementable with current long-reach excavators, though sections of the wall in the deepest portion of the incised buried channel in the southwestern part of the wall alignment would require excavation by clamshell. Such a wall would require little maintenance, but water levels on either side of the wall would need to be measured and assessed to assure that the head difference across the wall would not be so great as to fracture the wall. A rough cost estimate was prepared for such a slurry wall and is presented in the table below. The estimated cost is approximately $15,000,000 before contingencies. The subcrop of the Upper Chinle aquifer under the wall alignment would pose a performance risk, as there would be a potential for contamination to bypass the wall via the Upper Chinle sandstone. This risk could be addressed through increased pumping near the subcrop, though this would reduce the operational cost savings. Additional study of this alternative is recommended.

Table 1	**Homestake Mine Slurry Wall Construction Estimate 1/27/10**				
Section	Length (ft.)	Avg. Depth (ft.)	$/SF	Excavate/Backfill Cost	
North	3800	80	$10.35	$3,146,400.00	(RECON $/SF)
NE	400	70	$10.35	$289,800.00	(RECON $/SF)
East	1700	60	$10.35	$1,055,700.00	(RECON $/SF)
SE	700	40	$9.25	$259,000.00	(RECON $/SF)
South	3400	85	$12.50	$3,612,500.00	(RECON $/SF)
SW	800	120	$14.75	$1,416,000.00	(RECON $/SF)
West	1600	95	$12.50	$1,900,000.00	(RECON $/SF)
NW	600	70	$10.35	$434,700.00	(RECON $/SF)
			Subtotal	$14,014,100.00	
Mobilization/Demobilization				$100,000	(RECON)
Equipment Setup				$50,000.00	(RECON)
Clay Cap on Top of Slurry Trench (13,000 LF X $ 59.50/LF)				$773,500.00	(RECON)
QC Testing/Final Report (1,041,000 SF X $0.40)				$416,400.00	(RECON)
Submittals/Reports				$8,000.00	(RECON)
			Subtotal	$1,347,900.00	
			Total Slurry Wall:	**$15,362,000.00**	
Assumes normal digging, no rocks, boulders or obstructions. No remote mixing.					
Assumes 30 inch wide slurry wall					

4.4.2 *Permeable Reactive Barrier*. Another alternative to remediating the uranium and other redox-sensitive contaminants in the groundwater that was considered is a permeable reactive barrier. Permeable reactive barriers (PRBs) passively treat contaminated groundwater through removal of contaminants as the groundwater flows through the reactive material that is placed in the barrier (SERDP 2000).

PRBs have been applied to uranium removal with different reactive materials. Granular zero-valent iron (ZVI) is the most common reactive material that is used (SERDP 2000); this was assumed to be the reactive material for the conceptual model for Homestake. The basic mechanism for uranium removal with ZVI is reduction of the uranium, which makes the uranium more insoluble, resulting in precipitation of the uranium.

Different configurations of PRBs can be utilized. The two most common are continuous reactive barriers (entire barrier contains the reactive material) and a funnel-and-gate configuration, where impermeable outer walls “funnel” the contaminated groundwater into the “gate”, which is the barrier with the reactive material. The latter is commonly used when a large groundwater plume needs to be remediated. As the size of the groundwater plume to be remediated at the Homestake site is large, this configuration was chosen for development of the conceptual design at Homestake.

Table 2 presents the calculations related to the PRB conceptual design and cost. A thickness of three feet was chosen based on the thickness of the wall used for treating uranium at Frye Canyon, Utah [EPA and USGS 2000]. The depth of the PRB is variable depending on the depth to tie into the Chinle Formation. This depth varied between 85 and 120 feet as shown in Table 2.

The cost of the gate portion of the PRB was estimated using cost information from the Federal Remediation Technology Roundtable (FRTR) Remediation Technologies Screening Matrix and Reference Guide, Version 4.0, 4.40 Passive/Reactive Treatment Walls (http://www.frtr.gov/scrntools.htm). Using the volume of reactive material in the gate, the resulting gate cost estimate is approximately $19,000,000 before contingencies.

Note that the estimate is only the capital cost of the wall and does not include monitoring and maintenance costs. It is expected that the PRB would continue to operate as long as the uranium concentrations upgradient of the wall remain above the clean up goal of 0.16 mg/L for the alluvial aquifer. This would likely require decades. Given the long operating life, the potential for deposition of minerals from the relatively high TDS would need to be considered. An estimate of the potential for mineral deposition can be obtained from data from the Denver Federal Center PRB. At that site, with a TDS of 1200 ppm, a surface permeability loss up to 14% was observed after four years operation (FRTR 2002). As the TDS in the alluvial aquifer is approximately 2500 ppm, with some TDS concentrations near the tailings piles up to 20,000 ppm (Homestake, 2009), there is the potential that the ZVI would need to be rehabilitated or replaced periodically during the life of the barrier.

As with the slurry wall option, there is a potential for migration of contaminants through the Upper Chinle aquifer that subcrops under the large tailings pile. This may require continued extraction and treatment of ground water. Because of the relatively high capital cost, the significant potential recurring iron replacement costs, the long remediation times, and the risk of flow past the PRB in the Upper Chinle, this technology is not recommended for use at Homestake.

Table 2	Homestake Mine PRB Wall Construction Estimate					
Section	Length (ft.)	Avg. Depth (ft.)	$/SF	Excavate/Backfill Cost	Notes	
South Funnel	3500	85	$12.50	$3,718,750.00	(slurry wall)	(RECON $/SF)
SW Gate	800	120	$127.50	$12,240,000.00	(iron filings)	(FRTR $/SF)
West Funnel	2000	95	$12.50	$2,375,000.00	(slurry wall)	(RECON $/SF)
			Subtotal	$18,333,750.00		
Mobilization/Demobilization				$100,000		(RECON)
Equipment Setup				$50,000.00		(RECON)
Clay Cap on Top of Slurry Trench (5500 LF X $ 59.50/LF)				$327,250.00		(RECON)
QC Testing/Final Report (583,500 SF X $0.40)				$233,400.00	(entire wall)	(RECON)
Submittals/Reports				$8,000.00		(RECON)
			Subtotal	$718,650.00		
			Total PRB Wall:	**$19,052,400.00**		

Note: Estimate based on marked -up budget costs from RECON and FRTR w/ expected range of accuracy +25% to -25%
Estimate assumes normal digging, no rocks, boulders or obstructions and no remote mixing.
Assumes 30 inch wide slurry wall funnel for south and west sections and 30 inch wide iron filled gate for SW section
Assumes PRB gate filled with iron filings full depth

4.4.3 *In-Situ Immobilization*. In-situ immobilization, using an amendment to reduce the mobility of the contaminants, was also evaluated. This technology was evaluated in detail for the specific technology of polyphosphate immobilization of uranium given the information available and success of application in a pilot study at the Hanford facility in Eastern Washington (Wellman, et al, 2007) in treating uranium in groundwater. In this technology, uranium in the aquifer is sequestered through reaction of phosphate with uranium to form relatively insoluble and stable uranyl phosphate minerals. The use of polyphosphate (polymerized phosphate) allows reduction of the rate of reaction of the phosphate with the uranium and other metals in groundwater, increasing the potential for wider distribution of the amendment in the aquifer and decreasing the potential for injection well clogging. Though the concept was assessed for treatment of the materials below the tailings, a similar concept could be applied to the tailings themselves. The considerations discussed below would generally apply to the tailings.

Hydrogeological and geochemical information was supplied to the Hanford team for assessment of application of the polyphosphate immobilization technology to Homestake. The information (largely derived from 2006 CAP report and the Homestake site database) included the following:

- Subsurface materials - a heterogeneous mix of silt, sand, and gravel.
- Hydraulic conductivities of 30-100 ft/day, but varies 1-800 ft/day,
- Ground water chemistry and contaminant data: Primary cation is sodium (3000-4000 ppm vs 10-20 ppm total for Ca, Mg, K). Anions split between sulfate (3000-5000 ppm), bicarbonate (2000-4000 ppm), carbonate (600-1600 ppm), and chloride (250-1000 ppm). pH values are 9.5-10. Redox is slightly negative but limited data. Uranium concentrations 2-12 ppm (possibly higher), and selenium 0.3-3 ppm.

It was determined through discussions with the Hanford team that the conditions at Homestake were significantly different from those at Hanford. The pH is slightly alkaline at Hanford but strongly alkaline at Homestake, and there is a much larger range of hydraulic conductivity at Homestake compared to that at Hanford. The former potentially results in the formation of different uranyl-phosphate species and the latter affects the amount of polymerization of the polyphosphate, thus the retardation of the phosphate-uranium reaction rate, used in the application. It was the conclusion of the Hanford team that these differences would require substantial lab and pilot scale testing for determining the application of the technology to Homestake. It is estimated that these technology application activities would cost at least $5 million.

Assuming that the polyphosphate technology could be tailored to Homestake, the following field scenarios were prepared:

- Alternative 1 - Treat under entire pile. A 70 feet depth on average and an area of 8,000,000 sq ft under the tailings pile was assumed as needing treatment, resulting in 560 million cu ft or ~ 21 million cu yd.

- Alternative 2 - Treat under the pile in perched water zone. This would be roughly 4/7ths of the volume of alternative 1 (40 feet of the 70 foot depth is above the water table) or 12 million cu yd.

- Alternative 3 - Create a horseshoe-shaped treatment zone below the water table around the pile, including 10 feet of soil above the water table. A 50-foot width was assumed for the barrier along 2/3 of the perimeter (12,000 feet) on the downgradient and side gradient edges of the pile, or a total 18,000,000 cu ft (670,000 cu yds). The vertical 10-foot-thick barrier just above the water table, which would inhibit mass loading on the water table would be 1/7th of the Alternative 1 total, or 3,000,000 cu yds, for a total of approximately 3.7 million cu yd.

Costs for Alternatives 2 and 3 were then estimated using information from Hanford and typical drilling costs. For costing Alternative 2, vertical well spacing of 25 ft was assumed in lines perpendicular to ground water flow separated by 250 feet, resulting in 14 lines with a total of 2570 wells, on average 110 feet deep or 280,000 feet of drilling. For Alternative 3, 6400 linear feet was assumed with 10 feet spacing, resulting in 640 wells at an average depth of 70 feet for a total of ~45,000 feet of drilling. Assuming costs of $60/foot for Alternative 2 and $50/foot for Alternative 3 (easier access than Alternative 2), costs of $16,800,000 and $2,300,000 for drilling and well installation were obtained, respectively, for Alternatives 2 and 3. It is noted that these costs do not include oversight, field geologist for logging, contingencies, etc.

An estimate of the cost of the materials was supplied by Hanford for each alternative. This assumed an approximate material cost of $30,000-$35,000/well. The resultant material costs were ~$32,000,000 and $8,000,000, respectively, for Alternatives 2 and 3. It is noted that these costs are for materials only and do not include material injection.

The total estimated costs for Alternatives 2 and 3 were then approximately $54,000,000 and $16,000,000. These costs are considered minimum costs as they do not include material injection and drilling documentation costs, as well as any cost contingencies.

It is noted that there are other in-situ immobilization technologies. These are mentioned briefly here. One group includes technologies that create reducing conditions, which can also immobilize uranium and selenium. There is evidence from the decreases in contaminants, particularly selenium (HMC, 2009a), that this is occurring with the current flushing program. It is hypothesized (HMC, 2009b) that the water injected for flushing may be coming into contact with organic matter in the slime present in the tailings deposited in the LTP. Flushing through the slime may have caused the flushing water to become more reducing [limited HMC geochemical data indicates this may be occurring (HMC, 2009b)]. The reducing conditions could then be carried down with the flushing water into the water retained in the LTP and the groundwater beneath the LTP. Precipitation of the uranium and selenium related to the more reducing conditions may then have resulted in reduction of the dissolved phase uranium and selenium concentrations.

The drawback of the technologies based on immobilization through creation of reducing conditions is the potential release of sequestered uranium and selenium if the reducing conditions become more oxidizing in the future, thus bringing into question the long-term effectiveness of the technology (Wellman et al., 2007). Two scenarios where this release may occur at Homestake are 1) flushing is discontinued and more oxidizing groundwater would travel through the aquifer below the LTP, and 2) as flushing is continued, the reducing effect of the slime may be lessened over time, with the flushing water, therefore the water in and below the LTP, becoming more oxidized.

The polyphosphate sequestration technology creates minerals that are stable under oxidizing conditions, therefore, has higher potential long-term effectiveness under a fuller range of aquifer conditions. There is also a relatively new immobilization technology that is still in lab development (Fryxell et al., 2005). The drawback of the latter is the lack of field application and the associated lab and pilot scale effort that would be needed to determine if this technology was appropriate for use at Homestake. Because of these drawbacks, these technologies are referenced but not described in detail in this report.

Recently, HMC (HMC, 2010b) has proposed the performance of two field pilots that are exploring the removal of uranium in-situ through adsorption or by in-situ precipitation. The first field pilot is to test the removal of uranium from groundwater through adsorption onto zeolite. The second field pilot is to test the removal of uranium from groundwater through the addition of amendments to induce in-situ precipitation of low solubility uranium phosphates or oxide. .

4.4.4 *Removal of Tailings*. The Department of Energy (DOE) is currently in the process of excavating, transporting, and disposing of the Moab uranium mill tailings site in Grand County, Utah. The DOE has designed and built a new disposal cell in Crescent Junction, Utah, 30 miles from the Moab site. The amount of waste to be relocated to the new site has been estimated to be approximately 12,000,000 cubic yards. The Moab transportation will be completed using trucks and/or rail. The project is expected to be completed in 2019 with a current total completion cost estimate range of $844,200,000 to $1,084,200,000. These projected volumes and costs were used to develop a rough estimate of performing a similar relocation at the Homestake Mining Company Site. A scaling factor in $ per cubic yard was calculated using the lower end of the DOE estimate to account for tasks that would be similar and not dependent on disposal volume, such as cell design costs. For estimating purposes, it is assumed that all impacted material would be excavated and relocated to a new cell located a similar distance from the HMC site. By removing material from the site to levels that would satisfy the unrestricted release criteria in 10 CFR 40, the site would not require long-term stewardship. The significantly greater estimated volume of tailings, contaminated soil, and buried debris at the HMC site leads to a significantly higher estimated cost estimate than is currently in place for Moab. The cost of any long-term groundwater treatment that may be needed following the removal of the tailings has not been included in the estimate.

Table 3	**Estimate for Removal of All Tailings/Waste and Off-Site Disposal at a Newly Constructed 10 CFR 40 Compliant Cell**			
Area	In-situ Mass (ton)	Excavated. Volume (yd³)	Moab $/yd³	Estimated Relocation Cost
LTP and Cover	28,000,000	26,000,000	$70	$1,800,000,000
Soils Beneath LTP	11,000,000	10,000,000	$70	$700,000,000
STP/EP	1,300,000	1,500,000	$70	$100,000,000
Mill Pits	700,000	800,000	$70	$56,000,000
	41,000,000	38,000,000		
			Total Cost	$2,700,000,000
Volume assumptions are: minimal segregation of cover material; removal of contaminated soil beneath the LTP; density of 1.3 tons per cubic yard in-situ; an over excavation factor of 25 percent for the STP and Mill areas; a volume expansion of 20 percent after excavation; and volumes and costs rounded to two significant digits.				
Moab cost per cubic yard is estimated from the July 2009 Department of Energy, Office of Environmental Management Report on Annual Funding Requirements, Moab Uranium Mill Tailings Remedial Action Project.				

The Department of Energy completed a Final Environmental Impact Statement (FEIS) for the Remediation of the Moab Uranium Mill Tailings in July 2005. In accordance with the National Environmental Policy Act, the FEIS considered the unavoidable adverse impacts, the relationship between short-term uses and long-term productivity, and the irreversible or irretrievable commitment of resources that would occur if the off-site disposal alternative was implemented. A similar analysis would need to be performed at the Homestake site. As part of the RSE Addendum work, the removal of HMC materials was modeled in the AFCEE Sustainable Remediation Tool (SRT) Version 2 (Jan. 2010). The SRT provides an estimate of the carbon dioxide emissions to the atmosphere, the total energy consumed, and the safety/accident risk of completing the soil excavation.

For the Large Tailings Pile removal, the SRT calculates that approximately 270,000 tons of carbon dioxide would be emitted during the project. Energy needs would be large, equivalent to 1.0 billion kilowatt-hours (the power needed annually to run 96,000 homes). Because of the significant amount of construction and truck traffic needed to move the HMC material, the predicted loss of work time, 6,600 hours due to an estimated 140 injuries is significant. Copies of the SRT worksheets are in Appendix C. Note that using a rate of 1.5 fatalities per 100,000,000 miles driven (ITRC Remediation Risk Management Technical Regulatory Guidance, in press) and a total of 150,000,000 miles driven (assuming disposal 20 miles away), it is a strong possibility that there may be a fatality during the project. There are other potential risks associated with the disruption of the tailings pile, including an increase in radon and dust emissions, though engineering controls can be applied to mitigate these impacts.

Note that tailings relocation would represent a large positive economic impact to the Milan/Grants area, offering significant employment for a number of years. The employment and project related spending would have ripple effects through the rest of the local economy.

For comparison, the carbon loading, energy use, and accident risk for the current ground water extraction and treatment system and for a slurry wall and associated reduced pump and treat system have been calculated and are presented in Table 4. The impacts of the relocation of the tailings pile significantly exceed the impacts of both the current system and the slurry wall alternative. The current extraction and treatment system would have to operate for approximately 150 years to equal the energy use and carbon emission impacts of the tailings pile relocation (using trucks). The important (but somewhat arbitrary) assumptions include:

- Current pump and treat system would operate with 95% up-time for 50 years to control plume migration from the large tailing pile and requires 4 persons to operate living 5 miles away
- A slurry wall would result in a 75% reduction in required pumping during the first 25 years and an 88% reduction in required pumping for 25-75 years, along with a reduction in staffing of 1 person compared to existing system
- Total electrical demand is dominated by an estimated 300 HP for electric motors (for pumps, sprayers, compressors, etc.) and motor efficiency is 80%
- Bentonite (for slurry wall) haul distance is 1000 miles from northeast Wyoming to site (in the SRT, used mulch as surrogate for bentonite)
- Efficiency of electrical production is not considered (some references indicate a production and transportation efficiency for electricity at 33%)
- Ground water monitoring impacts are not included

- Energy use in preparing a lined repository site for a relocated tailings pile was not included

Table 4. Comparison of Energy Usage, Carbon Emissions, and Accident Risk for Current Remedial Approach and Alternative Remedies

Technology	Life-Cycle Energy Use* (kW-hr)	Life-Cycle Carbon Emissions (tons)	Estimated Number of Lost-Time Accidents
Current Ground Water Extraction and Treatment	*360,000,000*	*81,000*	*0.4*
Tailings and Underlying Soil Excavation and Off-Site Disposal	*1,000,000,000*	*270,000*	*140*
Slurry Wall Construction	*8,300,000*	*35,000*	*16*
Reduced Pumping with Slurry Wall	*97,000,000* *Total = 105,300,000*	*21,000* *Total = 56,000*	*0.46* *Total = 16.46*
***Life-cycle impacts for ground water extraction considers only operations, not construction**			

Based on suggestions from stakeholders, a simple analysis was conducted for the alternative of transporting the excavated tailings to an engineered repository 20 miles away via a slurry pipeline. A similar proposal was made to transport tailings from the Moab site (Hochstein et al., 2003). Although the proposal was not accepted, the computations for that project were roughly scaled to assess the energy usage for the Homestake site relative to the transportation by truck.

The Moab proposal involved transport of an estimated 400 tons/hour over 80 miles. The piping would include both a slurry pipeline and a water return line (to reduce use of water). Over 2,000 gpm of water would be required, of which 1,500 gpm would be returned. The Moab design included two pump stations each including three large (2100 HP) pumps capable of generating 2,800 psi, of which two would be active at any one time. The design also included a 1200 HP return flow pump.

Assuming that the Homestake production rate would be similar (400 tons/hour) to the Moab project, a make-up water flow of 500 gpm would be required. Given the shorter distance, only one pump station with smaller pumps (1500 HP) was assumed to be required for the Homestake project, and no pump was assumed to be required for the return flow, which could be gravity-fed given the difference in elevation between the assumed repository location and the Homestake site. Based on the estimate of mass in the tailings piles at the Homestake site, it would take more than six years to move the tailings. Assuming a 70% electrical efficiency (motor and pump), approximately 3200 kW would be required to run the pumps. For the duration of the project, over 180 million kW-hrs of electricity would be required.

This is a large energy use but it is significantly less than the energy required for trucking. Note that the SRT only provides the total diesel fuel consumed for both excavation and transport. Since the fuel use for excavation would be approximately the same for both trucking and slurry pipeline transport, the true comparison for transport can't be made. The accident risk for workers would undoubtedly be significantly less with the slurry transport. The potential environmental consequences of a pipeline break with relatively liquid slurry would likely be more severe than for a truck carrying tailing overturning along the haul route. The slurry system would result in the export of a significant amount of ground water from the vicinity of the site.

The cost estimate for relocating the Moab tailings by slurry pipeline was $122,000,000 in 2002 dollars. Based on a scaling of the capital and operating costs, as summarized in Table 5, the cost for transporting and handling Homestake tailings via slurry pipeline was estimated to be about $112,000,000. Note that this estimate has uncertain accuracy as the validity of the costs presented in Hochstein et al. (2003) was not evaluated.

Table 5. Cost Estimate for Slurry Transport of Homestake Tailings			
Based on Hochstein et al., 2003 Paper on Moab Tailings Relocation by Slurry			
Capital Costs			
Item	Hochstein et al. 2003 (Million $)	Adjustment for Homestake	Notes
Plant Prep	3	0	
Pump Stations	10.2	-5	Only one pump station
Pipelines	48.2	-36	Only 20 miles instead of 80
Dewatering Plant	8.1	0	
Control Systems	5.2	0	
Indirects, Contingency	22.3	-12.2	Proportional to reduction
Total	97	-53.2	
Homestake Capital Cost	$43,760,375		
Inflation Factor (2002 to 2010)	1.21		From http://www.bls.gov/data/inflation_calculator.htm
Current Dollars	$52,950,053.55		
Operating Costs			
Unit Cost from Hochstein	1.2	per ton	
Mass at Homestake	41,000,000	ton	
Operating Costs-Homestake	$49,200,000		
Inflation Factor (2002 to 2010)	1.21		
Current Dollars	$59,532,000		
Total Estimated Cost	$112,482,054		In 2010 dollars

4.4.5 *Alternative Energy Potential at the Homestake Site*. The site is located in the portion of the US with the most available sunshine and relatively high solar power density. According to a map from the Department of Energy (http://www.nrel.gov/gis/images/map_pv_national_lo-res.jpg) , the site is in a region with over 6000 W-hr/(sq m-day) photovoltaic solar resource. The placement of photovoltaic panels at the site could generate some of the electricity required for operations at the plant, or for sale. There are smaller regional transmission lines not too far north and south of the site. Though the economics may or may not currently be favorable, the opportunity exists to showcase the use of “green” energy at a contaminated site.

One drawback posed by the site would be the difficult geotechnical properties of the tailings pile. The pile has undergone settlement, and if dewatered, additional settlement would likely occur. This would likely adversely affect the orientation or even stability of the panels. The foundation improvement that would likely be required would add significantly to the cost. Placement of panels on other tracts of land around the piles would be more feasible.

The site does not appear to offer adequate average wind speed to justify a large wind turbine project (see http://www.windpoweringamerica.gov/images/windmaps/nm_50m_800.jpg), but may have adequate wind resource to power a few smaller generators for on-site use.

5 RECOMMENDED MODIFICATIONS TO THE EXISTING TREATMENT PLANT

5.1 Evaluation Basis. The basis of the evaluation of the RO treatment process was the flow rates and species concentrations estimated for the revised remedial strategy discussed in section 4.1. These flow rates and concentrations were based on earlier dewatering rates and observed sump concentrations. Comparison with the flow rate and species concentrations currently used at HMC (Table 6) indicates that the feed species concentrations proposed in are all comparable or lower than those currently in the feed into the RO treatment plant. The feed rate, although higher, is still well below the average yearly feed rate of 540 gpm as estimated as achievable by HMC (HMC, 2010a). This indicates that the capability of the current treatment system to treat the feed under the proposed alternative remedial strategy discussed in section 4 is not a constraint.

5.2 System Constraints. An apparent constraint on the capability of the current treatment system, however, as indicated in section 6, is the capacity of the evaporation ponds or other holding capacity to receive the waste brine from the RO treatment plant in combination with other waste streams. As indicated in section 6, the evaporative capacity of the current Pond system, assuming direct disposal of the highest concentration water from the tailing piles and the estimated brine from treatment of the 450 gpm feed stream proposed in section 4, is short by 20-40 gpm, assuming continued operation of the active evaporation spraying. Modifications to the treatment system were then evaluated to first address this shortfall.

5.3 Alternatives to Current Treatment Operation. One approach to addressing this shortfall is increasing the amount of treatment of the water collected downgradient of the Tailings Pile that is currently directly conveyed to the evaporation ponds. This would then allow more volume of brine from the RO treatment system to go the Ponds. HMC has proposed and is currently developing the infrastructure for a pilot using the East Collection Pond for mixing some of the collected water from Tailings Pile, which is rich in calcium, with water pumped from the alluvial aquifer along the L line, which is rich in bicarbonate. The hypothesis is that calcium carbonate (the bicarbonate reacting to form carbonate) will precipitate out, with the now lower TDS water then being fed into the clarifier and subsequent completion of the RO treatment process. HMC is proposing to start with a 10 gpm flow rate in the pilot and then using increased flow rates as the process is developed (HMC, 2010a).

Another approach to decreasing the capacity shortfall is to increase the RO product to brine ratio. This is most simply accomplished with the existing RO system by adding an additional high pressure stage(s). This is currently the configuration for the original two stage RO unit, with the high pressure stage extracting approximately 16% more product from the incoming feed by recirculating the brine from the low pressure stage through the high pressure stage (the current high pressure unit produces approximately 40 gpm more product based on a 250 gpm influent flow rate). The disadvantage of the higher pressure is the increased electrical costs to run at the higher operating pressure so the higher operating costs need to be weighed against the increased product output. Also, as the current low pressure unit is newer than the original low/high pressure unit, the efficiency in product to brine ratios may not be as high [the operating data from the 9-14-09 and 9-22-09 logs suggests that the more recent low pressure RO unit has a higher product to brine efficiency (HMC, 2009c)].

Another approach to meeting the capacity shortfall is other technologies that could remove the uranium, selenium, and molybdenum with lower or no waste production. In considering these technologies, it was assumed that pretreatment for TDS reduction would be necessary as the average TDS and sulfate concentrations (5800 and 2900 mg/L, respectively) in the feed are above the discharge standards for reinjection (alluvial aquifer standards of 2734 and 1500 mg/L, respectively). It was therefore assumed that the feed would go through the pretreatment part of the current RO treatment process but a portion could be diverted to another treatment media.

The first alternative treatment media considered was ion exchange. Although the same resin that designated as being highly selective for uranium for potential treatment of the irrigation water (refer to section 8) was a candidate, the feed for the treatment plan, unlike the irrigation water, also has selenium and molybdenum well above aquifer standards. Although it is feasible to add an additional ion exchange column to remove the molybdenum, no ion exchange resin was found that could reliably remove selenite (SeO_4^{-2} or $HSeO_3^-$), which is one of the anionic forms of selenium that may be present in the treatment plant feed. Therefore, this option was eliminated from further consideration.

The second alternative treatment media considered was zero valent iron (ZVI), which has the potential to remove uranium, molybdenum, and selenium through precipitation by inducing reducing conditions. It was assumed that the shortfall of 40 gal/min of flow would be diverted after pretreatment of the feed. Using the design criteria for retention from the Fry Canyon Site of a 3' thick wall with a 1.5 ft/day groundwater velocity, it was calculated that costs of the ZVI material necessary for treating the 40 gpm shortfall would be approximately $200,000, with an additional $100,000 estimated to pilot test, construct, design, and install the column. This option was eliminated from further consideration both because of the relatively high cost for the amount of additional product obtained and because of concerns about the plant size allowing the amount of ZVI material (200 cu yds) estimated as necessary for treatment.

In summary, the current treatment system appears to be capable of treating the feed from both the current operations and the feed proposed as an alternative as a result of the RSE Addendum effort; however, the treatment plant throughput is constrained because of the limitations of the capacity for waste disposal. The two most implementable approaches for optimizing the treatment system that would decrease the shortfall in waste disposal capacity are 1) the treatment of the high TDS tailings water (currently being pumped directly to the waste ponds), with a pretreatment salt precipitation in the East Collection Pond before treatment in the treatment plant and 2) augmentation of the low pressure only RO unit with a high pressure stage. These two approaches in combination may meet the present shortfall in waste disposal capacity although actual decreases in shortfall would need to be determined from pilot tests.

Although not directly related to optimization of the RO treatment system, the feed rate proposed in Task 1 could also be achieved through increase in the waste disposal capacity through Pond capacity expansion. The alternatives for Pond expansion, with varying degrees of evaporation spraying, are discussed in detail in Section 6.

Table 6. Comparison of Average Flow Rates and Species Concentrations for Current and Proposed Treatment Systems Feed

	TDS (ppm)	U (mg/L)	Se (mg/L)	Molybdenum (mg/L)	Flow rate	
Feed HMC	5800	13.4	1.3	17.4	415	(avg late Sept 2009)
Revised Feed	3600	6.7	1.8		450	

6 EVAPORATION RATES AND NEED FOR ADDITIONAL EVAPORATION CAPACITY

6.1 Estimate of Lake Evaporation Assuming Fresh Water. An estimate of the annual lake evaporation rate for fresh water from the existing ponds was developed using the procedure presented in Appendix D. Based on that analysis, a maximum 124 gallons/minute (annual average) could be evaporated. This does not account for the salinity of the existing liquids in the pond.

6.2 Effect of Salinity. To estimate the reduction in evaporation rate because of the brine, it was assumed that the water in the ponds was fully saturated brine. Using the brine and fresh water plots from M. Al-Shammiri "Evaporation rate as a function of water salinity," Desalination 150 (2202) 182-203, an approximate rate reduction of 50% for brine compared to fresh water was obtained. This would suggest that an approximate evaporation rate for the brine of 62 gpm. This compares to the passive rate of evaporation measured by Homestake of approximately 80 gpm. It is noted that all these calculations are an average over the year, with summer evaporation expected to be higher and winter evaporation to be lower. It is also noted that evaporation rates vary between studies, as well as the interpretation and application of results of the studies specifically to Homestake. For example, Homestake has referenced the Salhotra et al. 1985 study as indicating a reduction of 10% from fresh water to brine. The 50% rate from the Al-Shammiri study, adjusted upwards by the factor of 80/62, is used in the remainder of this discussion as an illustrative example but with the reservation that any sizing of ponds would need to use field data directly collected from Homestake to accurately predict the relationship between brine concentration, pond area, and evaporation rates.

6.3 Need for Additional Evaporative Capacity. Since 80 gpm is less than the current flow rate into the ponds (~170 gpm), there appears to be a need for additional measures beyond passive evaporation. It is anticipated that an average evaporative capacity of 200 gpm is required (see Appendix D). The current operation is utilizing evaporative spraying to augment the evaporation rates, with the combined passive and augmented evaporation rates being approximately double the passive evaporation rates. For the existing operating ponds, this results in an evaporation rate of 160 gpm. Assuming evaporative spraying is continued at the same level as present, the shortfall of 40 gpm could be accomplished by expanding the existing pond capacity by approximately 11 acres (see Appendix D).

If evaporation sprayers were used only on the new evaporation pond of 30 acres, (use only of passive evaporation on Ponds 1 and 2), the evaporation rate is estimated to be 190 gpm, which is less than the 200 gpm flow rate. The calculations indicate a potential need for approximately 36 acres surface area instead of the 30 acre surface area of the pond currently being constructed (see Appendix D). It is noted, however, that only surface evaporation, not additional pond volume, was assumed in calculating the brine capacity for the third pond of 36 acres. Therefore, it is not expected that any immediate shortfall of capacity will result if evaporative spraying was used only on the third pond currently being constructed.

If evaporation sprayers were not used on any of the ponds, the estimated total evaporation rate would be 135 gpm. Again assuming a flow rate of 200 gpm and capacity from only passive evaporation from the three ponds, the additional capacity beyond the two operating ponds was calculated to be 52 acres. This indicates the potential limitation of brine capacity on the complete discontinuation of evaporative spraying.

In summary, these calculations suggest that additional evaporative capacity is necessary for the proposed flow of 200 gpm if the current system or less spray evaporation is used. If the current evaporation spraying level is continued on all ponds, including the 30-acre third pond currently under construction, there appears to be adequate long-term evaporative capacity. If spray evaporation was discontinued on Ponds 1 and 2, a slight evaporative undercapacity was predicted. However, this undercapacity could be met by the increase in volumetric capacity from the third pond, which was not taken into account in the calculations discussed here. Finally this analysis suggests that a long-term pond evaporative undercapacity would result if spray evaporation was discontinued on all ponds.

Another way to increase evaporative capacity is to optimize the current Turbomist evaporation setup or equipment. A detailed evaluation of the different evaporation augmentation equipment is beyond the scope of this RSE. However, it is recommended that Homestake review and consider the information supplied by TASC. This information, which includes an article comparing different types of evaporative sprayers, additional facts on the Turbomist system, and several web addresses with information on evaporative sprayers is included in Appendix E.

The USACE recommends that for whatever option is adopted, including hybrids of the example options above, the option be well developed with site specific and design information to provide accurate predictions of the long-term evaporative capacity needs. Also, the USACE recommends that the size of the additional evaporation pond be based on the amount of evaporative capacity as calculated from the actual mix of evaporation and treatment equipment and operation that will be employed. This will ensure that the evaporation capacity of the additional pond will be adequate to meet the long-term evaporative capacity needs of the site.

7 GROUNDWATER MONITORING NETWORK AND AIR MONITORING PROGRAM

7.1 Groundwater Monitoring.

7.1.1 *Environmental Monitoring Objectives*. The rationale for collecting samples from each well at the Homestake site is not clear (though some wells are compliance points and are required to be sampled). Some samples may be collected to support specific operational decisions for the extraction and injection systems, and these needs may change year to year or even month to month. A more strategic approach to monitoring may allow a significant streamlining to the monitoring program yet provide a program more focused on the true objectives of the sampling. The primary reasons for collecting samples at the site include:

- monitoring progress of the source reduction due to flushing of the large tailings pile,
- monitoring of the containment of the alluvial aquifer plume emanating from the tailings piles to assure capture,
- monitoring the containment of the downgradient uranium and selenium plumes in the alluvial aquifer west and southwest of the site,
- monitoring of the concentrations and lateral and vertical extent of the downgradient plumes in the alluvial aquifer to track the response of the plumes to reductions in mass flux from the sources,
- verify the boundary between saturated and unsaturated alluvium
- monitoring of the capture and migration of the Chinle plumes
- monitoring concentrations at possible exposure points (domestic or irrigation wells), and
- compliance with existing licenses and permits.

A program that relates every sample to one or more of these objectives would be appropriate. The program should specifically identify the appropriate ("optimal") network, sampling frequency, and analytical suite.

Note that the Access database of sampling results and other observations from the Homestake is a very powerful data management tool, especially given the massive amount of data that have been generated over the past 35 years or more. However, there were noticeable errors in the database, such as in the measurement point elevations for certain C series wells as noted above. An effort to identify and fix such errors should be conducted, and it may be necessary to review the quality control processes for data entry to the site database.

Ground water piezometric measurements are necessary to:

- identify ground water flow direction changes that may affect plume migration
- support determination of capture zones for the extraction and injection systems
- support analysis of the lateral extent of saturated alluvium

Ground water piezometric monitoring should be addressed as part of the monitoring program planning and in the future each event should represent a relatively complete snapshot of the aquifer conditions over one relatively short period of time. The water levels in wells near the limits of the saturated alluvium should be compared to estimated top of rock elevations to assess changes in the extent of saturated alluvium and the amount of ground water requiring capture.

7.1.2 *Monitoring Network*. The Homestake site monitoring program includes a very large number of available wells for sampling and water level measurement, comparable to any of the largest remediation sites in the US. There are more than an adequate number of wells available for monitoring the conditions in the alluvial aquifer. There are a number of areas at the site that could be adequately characterized with fewer sampled wells due to the proximity of the currently sampled wells, including the area near the former mill, downgradient of the southwest corner of the large tailings pile, and near the evaporation ponds. The monitoring within the large tailings pile needs to be standardized with specific wells suitably screened within the tailings used for monitoring. The use of the dewatering/injection wells with very long screens makes the interpretation of the results very difficult. It is likely that the number of wells sampled in the large tailings pile could be decreased, provided the remaining wells are adequately distributed and represent the ambient conditions.

The monitoring networks for the Chinle aquifers are sparser than for the alluvial aquifer. In evaluating the available data for the Upper and Middle Chinle aquifers, it is apparent that there are areas where the plumes are not well bounded, particularly in the northern portion of section 35, north of Broadview Acres. Additional sampling would appear to be necessary there. In addition, additional wells would be useful to bound plumes in the Upper Chinle aquifer southeast of the large tailings pile, and in the Middle Chinle around CW-1.

7.1.3 *Monitoring Frequency*. Based on a review of ground water samples taken in 2008 and 2009 (through July), approximately 365 wells were sampled at some point in that period. Most wells did not appear to be sampled on a regular basis, but the sampling occurred with an approximate frequency of either annual (about 190 wells) or semi-annual (about 85 wells). Only about 15 wells had a sampling frequency that appeared to approximate a quarterly sampling schedule. At least 70 wells were sampled less than once per year. This represents a major investment in time and cost for the collection and analysis of the samples, and the validation and management of analytical results.

The frequency of sampling should be based on the use of the data and should consider the impact of unexpected results on decisions at the site, the time necessary to take action if additional actions are needed, the rate at which ground water may migrate, the timing of changes to the remedy that may affect the plume (e.g., significant changes in the pumping or injection locations and rates), and the frequency with which the collected data are assessed by the project team. Given the nature of the alluvial aquifer ground water velocities (estimated to be on the order of magnitude of 500 ft/year), the nature of the potential human exposures at the site, the degree to which Homestake staff can rapidly respond to changes in the plume, and oversight given to the conditions at the site, the sampling frequency does not need to be extreme. Qualitatively, the sampling frequency could be annual, with semi-annual sampling at key locations upgradient, side-gradient, and downgradient of extraction systems. Compliance point wells should continue to be sampled according to all existing requirements.

7.1.4 *Sampling Methodology and Analytical Suite*. The current use of low-flow sampling appears to provide good quality data. The use of no-purge sampling techniques, such as Hydrasleeves and Snap samplers may be considered to reduce the time necessary to sample the wells. A demonstration of these techniques side-by-side with current practices could demonstrate comparability between results obtained using each method. Refer to the Interstate Technology and Regulatory Council Technical Regulatory Document on "Protocol for Use of Five Passive Samplers to Sample for a Variety of Contaminants in Groundwater" (ITRC, 2007). Note that any comparison should identify the presence of mineral precipitates, particularly iron oxides, in the monitoring wells that may act to accumulate radionuclides and to increase turbidity in samples. If any dedicated tubing or pumps appear to have such accumulations, the no-purge sampling methods may not be appropriate.

The analytical suite can be evaluated based on the known distribution of the site contaminants. Given the long history of sampling in most site wells, the expected contaminants in different portions of the site could guide what analyses are chosen for samples from those areas. Though it is not recommended to tailor the suite of analytes for each individual well, wells to be sampled could be grouped by their general location relative to the sources and the mobility of the various contaminants. Again, the objectives for the sampling need to be considered.

7.1.5 *Further Optimization Opportunities*. Given the size and complexity of the monitoring program at the site, further quantitative optimization studies for the program are likely to be warranted. Homestake is encouraged to apply tools such as MAROS, GTS, or the Summit monitoring optimization tools. Refer to the EPA/USACE Roadmap to Long-Term Monitoring Optimization (EPA 542-R-05-003, 2005, available at http://www.frtr.gov/optimization/monitoring/ltm.htm).

7.2 Air Monitoring Program

7.2.1 *Environmental Monitoring Objectives*. The broad objective for the air monitoring program completed annually at the Homestake site is to ensure compliance with the regulatory requirements of 10 CFR 40 and 10 CFR 20 with respect to the exposure of members of the public from licensed activities at the site. As stated in the Semi-Annual Environmental Monitoring Report for July-December 2008 that was transmitted to NRC in February 2009, the design of the monitoring program is closely based on the guidance contained in NRC's Regulatory Guide 4.14, Revision 1, which was published in April 1980. The Semi-Annual Report acknowledges that some monitoring activities differ from those presented in the Regulatory Guide but does not provide additional information to identify or support those differences. The air monitoring program requirements to ensure compliance with occupational dose limits for HMC workers are also discussed in the Semi-Annual Report, but the results of monitoring are not provided. The August 2008 NRC Inspection Report 040-08903/08-001, determined that routine occupational air monitoring was not required due to the lack of exposed dry tailings. Radon flux measurements are also performed annually and are reported in the Annual Monitoring Report.

7.2.2 *Monitoring Network*. The number and location of monitoring stations for particulate and radon gas sampling meet the minimum requirements outlined in Table 2 of Regulatory Guide 4.14. Those requirements are for continuous monitoring at three locations at or near the site boundary that have the highest predicted concentration of airborne particulates; one or more locations at the nearest residence or occupiable structure; one control location; and five or more radon gas monitors collocated with the particulate samplers. See monitoring locations map in Figure 21 below.

The Semi-Annual Report indicates that the predominant wind direction is from the Southwest and locations HMC-1, -2, and -3 are identified as the locations with the highest predicted air particulate concentration. No meteorological data for the monitoring period is provided to confirm that conclusion. Wind direction data from the on-site meteorological station should be collected during each monitoring period and presented in the report. HMC included a wind rose in the 2009 Annual Irrigation Evaluation Report submitted to NRC. A similar figure should be provided with the air monitoring results in the Semi-Annual Environmental Monitoring Reports.

Monitoring locations HMC-4 and -5 are considered by HMC to be representative of the nearest residence. This assumption appears appropriate for assessing the dose from windborne particulates from the HMC site. The number of monitoring locations for radon gas in the residential area may not be sufficient. Results of sampling conducted during June-December 2008 show that the highest radon concentrations are not associated with the locations in the dominant wind direction. In fact, the highest measured radon concentration for this period was associated with HMC-6, the location that is considered the control for air particulate sampling. This may indicate that the preferred radon pathway from the site is not dependent on wind direction but on some other process. It is likely that additional radon monitors, 2 to 3, located between the current monitoring stations near the residential areas would be cost-effective at assessing the apparent preferential radon pathway direction.

The number and location of control monitoring stations may not be adequate to meet the overall objective of ensuring compliance with the public dose limit in 10 CFR 20.1301. As calculated in Attachment 4 to the Semi-Annual Report, the Total Effective Dose Equivalent estimated for the maximum exposed individual is highly dependent on three assumptions: that the radon background from location HMC-16 is representative of background in the HMC-4 and -5 areas; that use of an occupancy factor other than 1 for the exposed member of the public is appropriate; and the equilibrium concentration ratio between radon gas and its decay products. The equilibrium issue is discussed in Section 7.2.4 below.

The HMC report should better describe why different background locations are appropriate for air particulates and radon gas monitoring based on observed pathway differences. Additionally, the use of multiple radon background locations should be considered as it may better represent the distribution of background radon concentrations in the area potentially impacted by Homestake effluent releases. Historical studies of other uranium tailings piles (Shearer, 1969) have observed that atmospheric radon concentrations were not impacted beyond a distance of 0.5 mile from the pile.

The use of occupancy factors is generally not allowed when comparing site boundary concentrations directly to those in Table 2 of Appendix B of 10 CFR 20. If 10 CFR 20.1302(b)(2)(1) is used to determine compliance with the public dose limit, an occupancy factor of 1 is generally required. See NRC position at, http://www.nrc.gov/about-nrc/radiation/protects-you/hppos/qa68.html. The use of an occupancy factor is allowed when calculating the dose for the maximum exposed individual, however, the 75% (271 days/yr) used in the calculation is for an average resident and may not be appropriate, unless confirmed annually, for some residents that are not away from home 6 hours per day.

Homestake is also required to monitor the radon flux from the LTP and STP on an annual basis. HMC uses two simplifying assumptions for determining compliance with the radon flux limit of 20 pCi/m^2s that should be confirmed. The assumption that the radon flux from the LTP side slopes has remained constant since 1994/1995 when last measured should be reconsidered given the amount of potential movement of contaminants within the pile caused by the flushing program. It is assumed that it will be also measured again as part of the final closure. The assumption that the flux from the large STP area covered by the evaporation ponds is 0 pCi/m^2s needs to be justified. Recent monitoring of the radon flux from EP-1 by HMC indicates that the flux is greater than 0 pCi/m^2s and the report calculations should be modified to include this new data. Though radon has the potential to diffuse into the ponds from the STP below, it is more likely that radium-226 in pond sludge may be providing a source of radon that could be easily released through the spraying program. The HMC assumption that the Rn-222 concentration in the evaporation pond water is equal to the Ra-226 concentration in the water is inconsistent with general groundwater conditions where the Rn-222 concentration is generally many times higher than the dissolved Ra-226 value. This assumption should be checked by sampling the pond water for Rn-222 and the estimation of Rn-222 released by spraying modified.

7.2.3 *Monitoring Frequency*. The air monitoring frequency currently implemented at the Homestake site is appropriate for meeting the overall objectives of the program.

7.2.4 *Sampling Methodology and Analytical Suite*. The radionuclides monitored at HMC, uranium, thorium-230, and radium-226 are all those identified in Regulatory Guide 4.14 except for lead-210. This discrepancy should be discussed in the reports and the basis for not including the radionuclide identified.

The air particulate data reported from the contract laboratory should be required to indicate actual results instead of less than the lower limit of detection. The error estimated by the laboratory for the uranium results should not be given as “not applicable.” Though mass spectroscopy method may have less inherent error than radiochemical methods, the total estimated error including air sampling, etc. should be determined. Changes were made in the 2009 Semi-Annual Environmental Monitoring Report to improve laboratory data reporting.

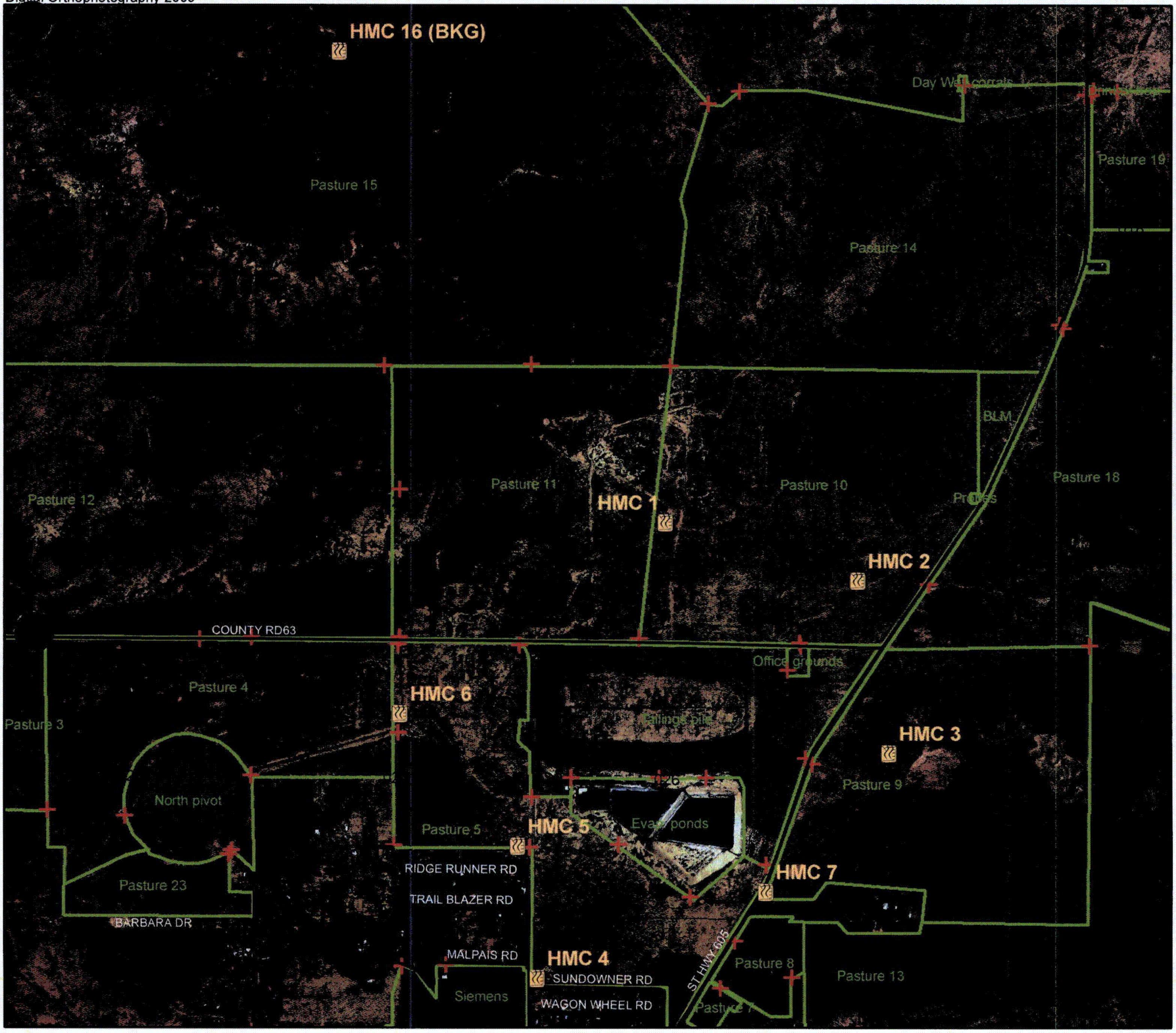
As identified in 7.2.2 above, the radon decay product /radon equilibrium fraction is extremely important in determining the dose from exposure to radon gas. Homestake assumes a 20% radon decay product equilibrium in their calculation of the committed effective dose equivalent to the maximum exposed individual. HMC should perform appropriate sampling to confirm the validity of the assumed equilibrium under various diurnal and seasonal fluctuations.

7.2.5 *Further Optimization Opportunities for the Site Monitoring*. As discussed in Section 8.1.3 below, EPA is currently panning for additional air and radon sampling within the residential areas of the site to support a human health risk assessment.

Figure 21.

Homestake Mining Company Properties
Grants, NM
Air Monitoring & Sampling Locations

Digital Orthophotography 2005



Location Id	Sampling Unit	Northing	Easting
HMC 1	Hi-Volume Particulate Monitor, Track -Etch Passive Radon Gas Monitor & OSL Gamma Badge	1547458.838	491370.45
HMC 2	Hi-Volume Particulate Monitor, Track -Etch Passive Radon Gas Monitor & OSL Gamma Badge	1546349.53	495053.16
HMC 3	Hi-Volume Particulate Monitor, Track -Etch Passive Radon Gas Monitor & OSL Gamma Badge	1543048.74	495640.47
HMC 4	Hi-Volume Particulate Monitor, Track -Etch Passive Radon Gas Monitor & OSL Gamma Badge	1538751.127	488918.03
HMC 5	Hi-Volume Particulate Monitor, Track -Etch Passive Radon Gas Monitor & OSL Gamma Badge	1541268.442	488546.31
HMC 6	Hi-Volume Particulate Monitor, Track -Etch Passive Radon Gas Monitor & OSL Gamma Badge	1543813.054	486297.26
HMC 7	Track-Etch Passive Radon Gas Monitor	1540395.708	493293.8
HMC 16 (BKG)	Track-Etch Passive Radon Gas Monitor & OSL Gamma Badge	1556470.456	485135.12

Air Monitors
Roads
Gates
Fence Lines
Section Lines

N W E S

FIGURE 1

0 0.25 0.5 1 Miles

8 IRRIGATION WITH CONTAMINATED WATER

8.1 Risk Issues. Since 2000, Homestake has applied uranium and selenium contaminated irrigation water to four fields corresponding to approximately 400 acres. Contaminant concentrations in the irrigation water and affected soils are sampled each year and a report summarizing the 2000-2008 monitoring program was published in March 2009. The 2009 Annual Irrigation Evaluation report, published by HMC in March 2010, includes measurements of selenium and uranium concentrations in hay grown on the irrigated land, a RESRAD dose assessment, and air dispersion modeling for radon released from irrigated lands.

8.1.1 *Uranium Radiological Dose/Risk Estimation*. The RESRAD computer code, Version 6.5, developed by Argonne National Laboratory was used to estimate the radiological dose and risk that may be incurred by a future resident living on the irrigated land. The RESRAD code uses a sorption-desorption ion-exchange model to estimate the leaching of soil contamination to groundwater. The leaching of uranium from the irrigated lands back into the alluvial aquifer was identified as concern by the RSE Advisory Group. The default contaminated zone area, 10,000 square meters, was used in the RESRAD calculation with a homogenous layer of contamination 2 meters thick with 100 meters parallel to the aquifer flow. The concentrations of the three uranium isotopes were input as 10 picocuries per gram (pCi/g) of uranium-238, 10 pCi/g of U-234, and 0.5 pCi/g of U-235. This activity corresponds to 30 mg/kg of natural uranium, and should be sufficient to address potential buildup from additional irrigation, if performed. Uranium decay products were initially set at 0 pCi/g and allowed to in grow over a 1000 year calculation period. Several site specific water and soil parameters were used and are highlighted in the RESRAD Summary Report in Appendix F All pathways in the model were included and the receptor was modeled to be present on-site 100 percent of the time, divided equally between indoor and outdoor activities. The results of modeling indicate that because of site specific conditions and the depth to groundwater in these areas, it is not expected that uranium in the upper two meters of soil will have a significant impact on groundwater in the alluvial aquifer. Because the dose, and risk, is mainly driven by external radiation exposure and ingestion of plants grown in the contaminated soil, the dose decreases rapidly after several hundred years as the uranium in the contaminated zone is removed by various processes, including erosion (erosion assumed to be 1 mm/yr, largely due to wind action).

The RESRAD model does not address the dose and risk from the use of contaminated irrigation water that is not associated with leaching from the contaminated zone. To assess the potential dose from the continued use of contaminated irrigation water, an additional RESRAD run was made using the same contaminated zone and irrigation rate yet leaving other soil and water parameters at the default settings. Using these inputs, contamination leached to groundwater and the uranium contaminated well water was then used for irrigation. The input soil concentrations were adjusted so that the leached uranium concentrations in well water were equivalent to the 0.44 mg/L total uranium irrigation limit that has been used since 2000. The resulting well water uranium isotope concentrations of 147 pCi/L U-238, 147 pCi/L U-234, and 6.1 pCi/L U-235 equate to 300 pCi/L total uranium which is equivalent to 0.44 mg/L assuming natural abundance. At the point in the model when the well water uranium concentrations had reached 300 pCi/L, the uranium levels in the contaminated zone had been significantly reduced by erosion. The resulting water dependent pathway doses are attributable only to the use of contaminated irrigation water. It is assumed that the resident will continue to use contaminated irrigation water while living on the contaminated zone, therefore the doses and excess cancer risks from all pathways are summed and presented in the Tables 7 and 8 below.

The largest contributor to the estimated dose and risk is the consumption of plants irrigated with contaminated water. Overall excess cancer risk is near the top of the CERCLA risk range 1E-06 to 1E-4. There are many conservative assumptions included in this estimate and none of the irrigated areas are currently inhabited. Two potential exposure pathways that were not included in this estimation were the direct ingestion of contaminated groundwater and use of water with uranium concentrations greater than 0.44 mg/L for irrigation.

Table 7	**Summary of Estimated Dose for Resident on Irrigated Land (mrem/yr)**		
RESRAD	Water		
Pathway	Independent	Dependent*	Total
Ground (External)	1.52	---	1.52
Inhalation	0.25	---	0.25
Radon	0.29	0.04	0.33
Plant	1.23	10.5	11.7
Meat	0.04	0.49	0.53
Milk	0.10	1.07	1.17
Soil	0.21	---	0.21
All Pathways	3.64	12.1	**15.7**

*Water dependent pathway doses are associated with the continued use of contaminated irrigation water at the historically limited concentration of 0.44 mg/L total uranium. All maximum water independent doses occur at year=0 except radon maximum water independent dose at year=1000 is used.

Table 8	**Summary of Estimated Excess Cancer Risk for Resident on Irrigated Land**		
RESRAD	Water		
Pathway	Independent	Dependent*	Total
Ground (External)	3.3E-05	----------	3.3E-05
Inhalation	1.5E-06	----------	1.5E-06
Radon	5.1E-06	7.8E-07	5.9E-06
Plant	1.4E-05	1.1E-04	1.2E-04
Meat	4.6E-07	4.4E-06	4.9E-06
Milk	1.1E-06	1.2E-05	1.3E-05
Soil	2.3E-06	----------	2.3E-06
All Pathways	5.7E-05	1.3E-04	**1.8E-04**

*Water dependent pathway risks are associated with the continued use of contaminated irrigation water at the historically limited concentration of 0.44 mg/L total uranium. All maximum water independent risks occur at year=0 except radon maximum water independent risk at year=1000 is used.

8.1.2 *Selenium Soil Screening Level Comparison*. In the March 2009 Irrigation Report, Homestake compared the selenium concentrations measured in hay to the National Research Council maximum tolerable concentration (MTC) for selenium in cattle feed of 2 mg/kg. This is an important consideration as the average selenium concentrations have historically been slightly below the MTC. In 2009, different grasses were planted and may concentrate selenium better than the previous hay varieties. The actual concentration should be confirmed prior to using the grasses for cattle feed.

The EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites web-based calculator, http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search, provides a resident noncarcinogenic risk-based screening level for selenium in soil of 391 mg/kg. This is well above levels in the irrigated areas. Even considering the multiple contaminants present, the uptake of selenium in plants potentially used for cattle feed is more of a concern at the levels currently present.

8.1.3 *EPA Risk Assessment*. EPA is currently planning to implement additional sampling throughout the residential and irrigated areas to support a complete human health risk assessment. EPA has discussed the scope of work for the risk assessment with the RSE advisory group.

8.2 Future Alternatives.

8.2.1 *Treatment of Irrigation Water*. An alternative to the current practice of directly applying untreated extracted groundwater for irrigation is removal of contaminants above the discharge levels through treatment before application to the land.

Currently, the maximum allowable concentration of uranium (0.44 mg/L) in irrigation water is based on NRC effluent release criteria and the maximum allowable selenium concentration is based on a site-specific background value. Though not specifically applicable to irrigation water, the New Mexico Water Quality Control standards for uranium (0.03 mg/L) and selenium (0.05 mg/L) are much lower than the irrigation discharge maximum concentrations. This alternative is developed in response to stakeholder concerns and to provide the regulatory agencies with a potential course of action for treatment, regardless of the driving reason.

A treatment system similar to that currently used in the treatment plant (chemical pretreatment, followed by removal of salts and metals by reverse osmosis) was considered impracticable because of the long distances needed to transport the reject water from the chemical pretreatment to the evaporation ponds (4-5 miles by road) and the undesirability of transporting waste through the residential communities in which the areas of irrigation are located.

An alternative treatment alternative was developed using ion exchange. The relatively high calcium and bicarbonate concentrations in the irrigation water suggests the uranium is either in a non-ionic form or is present in an anionic form. If present in a non-ionic form, pretreatment of calcium by ion exchange with a cationic resin may be necessary and would result in the uranium forming anions that would be treated by available uranium removal resins. The pretreatment would result in the need to regenerate the softening resins. The brine from the regeneration would need to be transported to the evaporation ponds. Based on brine production in municipal softening system, this is not expected to be excessive, but would represent additional effort and truck traffic back to the main treatment plant.

The irrigation water chemistry (Table 9) was provided to REMCO Engineering (805-658-0600, http://www.remco.com/ixidx.htm), who indicated that the company has resin(s) highly selective for uranium. The capital costs for a uranium treatment system (two columns in series with a particulate filter, assuming use of existing extraction well pumps to pump the water to the treatment plant) are estimated to be ~$750,000, with O&M costs of approximately $100,000 per year (assuming 400 cu ft of resin would be used at a cost of $200/cu ft). Spent uranium-specific resin could be either disposed of on-site or off-site. On-site regeneration of the resin through the use of a sodium chloride brine may be an alternative (see for example, http://www.adedgetech.com/uranium.html). In this case, the brine would be collected and trucked to the evaporation ponds for disposal.

Table 9. Average Concentrations of Species in Homestake Untreated Irrigation Water

Species	**Average**	**Species**	**Average**
Cations	Conc (mg/L)	Anions	
Sodium	285	Bicarbonate	460
Potassium	8	Carbonate	0
Magnesium	65	Sulfate	840
Calcium	242	Chloride	180
Dissolved Iron	0	Nitrate	3.5
Metals			
Uranium	0.28		
Selenium	0.06		

8.2.2 *Reduction of the Mobility of Uranium in Soil*. Although leaching of uranium is not considered to be a likely risk, mobility of the uranium in the irrigation soil could potentially be reduced through application of soil amendments such as organic-rich materials (e.g., compost or manure) or a phosphate-rich material such as bone meal. Since the impacts to ground water were not anticipated to be significant, these options were not researched further, but may be considered if other information comes to light that suggests that uranium immobilization may be necessary.

9 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions. The current remediation systems have been successful at reducing concentrations in ground water at the site and Homestake/Barrick seems to have truly been conducting the work with the intent of restoring the environment. There are a number of major conclusions from the evaluation of the efforts.

- Ground water remediation is very unlikely to be achieved by 2017.
- Flushing of the large tailings pile is unlikely to be fully successful at removing most of the original pore fluids or to remediate the source mass present in the pile due to heterogeneity of the materials.
  - There is a potential for rebounding in contaminant concentrations in the pile following cessation of flushing.
  - The addition of water to the tailings complicates the capture of contaminated water from the alluvial aquifer
- Long screened intervals in wells complicate the interpretation of water quality in and below the large tailings pile.
- An additional source may be located in the vicinity of the former mill site
- Control of the contaminant ground water plumes seems to depend on both hydraulic capture and dilution
- Proposed pilot testing of immobilization approaches in and below the LTP may be valuable.
- There may have been widespread impacts on the general water quality (e.g., ions such as sulfate) of the alluvial aquifer since mill operations began, but the limited amount of historical data precludes certainty in this conclusion.
- Upgradient water quality has declined over time, primarily in the western portion of the San Mateo drainage and this may be affecting concentrations in northwestern portions of the study area.
- Ground water modeling has generally been done in accordance with standard practice. The seepage modeling likely overestimates the efficiency of flushing of the tailings.
- The control of a uranium plume in the Middle Chinle aquifer may be incomplete
- There are no apparent impacts to the San Andres aquifer, though the number of wells in the San Andres in the study area is relatively small.

- There is no indirect evidence of leakage from the evaporation and collection ponds, though the interpretation of water level and concentration data are complicated by the significant injection and extraction conducted in the immediate vicinity of the ponds.

- Current constraints to treatment plant operations include the evaporative capacity of the ponds, clarifier operation, and possibly RO capacity.

- Evaporation rates for the ponds at the site are likely to be in the 65-80 gpm on an annual basis when accounting for climatic conditions and salinity of the pond contents

- The monitoring program at the site is extensive and not clearly tied to objectives.
  - The potential monitoring network is very large, particularly in the alluvial aquifer. There may be redundancies in the network in a number of locations in the alluvial aquifer. Additional monitoring points are necessary in the Upper and Middle Chinle aquifers to better define plume extent and migration.
  - Monitoring frequency is irregular but generally from semi-annual to annual. Only a relatively small number of wells are sample more or less frequently in recent years.
  - Air particulate monitoring appears adequate to assess anticipated effluent releases from the site; however, there is a need to confirm assumptions regarding radon background, preferential radon flow direction and radon decay product equilibrium that may require additional sampling.
  - Potential for release of radon from the STP/evaporation pond area should be assessed.

- Irrigation with contaminated water has resulted in accumulation of site contaminants in the soil of the irrigated land. These accumulations are unlikely to migrate to the water table over time, however.

- Water used for irrigation could be successfully treated with ion exchange technology

9.2 Recommendations. Based on the analyses conducted, a number of recommendations are offered below. Note that regarding several issues, no specific recommendations are made, but the conclusions from the analysis could be used by all agencies and stakeholders in assessing future actions.

- The flushing of the tailings pile should be ended. If this is not adopted, a pilot test of the potential for rebound in concentrations should be conducted in a portion of the tailings pile. Monitoring should be conducted in depth-specific wells with short screen lengths.

- If the field pilots to reduce uranium concentrations in the groundwater through adsorption or in-situ precipitation are approved and the results from the pilots are promising, apply in larger scale to applicable portions of the LTP and the groundwater.

- Simplification of the extraction and injection system is necessary to better focus on capture of the flux from under the piles and to significantly reduce dilution as a component of the remedy.

- Further evaluate capture of contaminants west of the northwestern corner of the large tailings pile.

- If not previously assessed, consider investigating the potential for contaminant mass loading on the ground water in the vicinity of the former mill site.

- Further investigate the extent of contaminants, particularly uranium, in the Upper and Middle Chinle aquifers and resolve questions regarding dramatically different water levels in wells in the Middle Chinle.

- Additional collection of geochemical parameters, including dissolved oxygen and oxidation reduction potential, of the groundwater beneath and downgradient of the LTP to characterize the geochemical environment and the role that reducing conditions induced by the flushing have had in immobilization of the selenium (and the potential that cessation of the flushing may lead to less reducing conditions and release of the selenium).

- Consider geophysical techniques, such as electrical resistivity tomography to assess leakage under the evaporation ponds

- Assure decommissioning of any potentially compromised wells screened in the San Andres Formation is completed as soon as possible.

- Consider construction of a slurry wall around the site to control contaminant migration from the tailings piles. The decision for implementing such an alternative would depend on the economics of the situation. Though HMC has conducted previous economic analyses of this alternative, the analysis of the payback due to reduced (but not eliminated) cost of operations of the ground water treatment system was not attempted for this study, could be revisited in light of other recommendations.

- Relocation of the tailings by any means should not be considered further given the risks to the community and workers and the greenhouse gas emissions that would be generated during such work.

- Consider either the pretreatment of high concentration wastes in the collection ponds as is currently being pilot tested, or adding RO capacity to increase treatment plant throughput and reduce discharge to the ponds

- Review of the spray evaporation equipment and potential optimizations of the equipment to increase the rate and efficiency of evaporation.

- Develop a comprehensive, regular, and objectives-based monitoring program.
  - The evaluation should identify redundant alluvial aquifer wells for exclusion from the program (e.g., near the former mill site and southwest of the large tailings pile).
  - Identify additional well locations required in the Chinle aquifers to better define the plumes.
  - Sampling frequency should be annual with semi-annual sampling in critical areas.
  - Quantitative long-term monitoring optimization techniques are highly recommended.
  - Any optimization effort should include an open discussion with stakeholders.
  - Consider passive samplers.
  - Perform sampling of radon decay products to confirm equilibrium assumption.
  - Consider use of multiple radon background locations to better represent the distribution of potential concentrations.
  - Reconsider the use of the 0.75 occupancy factor and use a value of 1 in accordance with NRC guidance.
  - Assess the concentration of radon in evaporation pond water and the radon gas potentially released from the evaporation ponds, especially during active spraying.

- Though risks appear minimal with the current irrigation practice, consider treatment of contaminated irrigation water via ion exchange prior to use as a means of removal of contaminant mass from the environment.

9.3 Approach to Implementation of Recommendations. Some of the recommendations can and should be implemented without consideration of other recommendations. Some recommendations can only be implemented in conjunction with others or depend on the outcome of additional characterization or studies. A suggested approach to implementation of the recommendations is provided here.

The recommendations that should proceed independent of any other recommendations include: 1) the evaluation of the potential escape of contaminants at the northwestern portion of the site, 2) the evaluation of the vicinity of the former mill site as a potential source of ground water contamination, 3) further characterization of the extent and migration of the Chinle plumes, 4) complete decommissioning of potentially compromised San Andres wells, 5) development of a comprehensive, optimized monitoring program, and 6) implement treatment of contaminated irrigation water to remove contaminant mass from the environment.

Several recommendations should be part of a fresh look at the overall ground water remediation strategy for the area around the tailings piles. Tailings flushing should be discontinued in conjunction with revamping of injection locations in the alluvial aquifer to minimize recirculation of water. At the same time, pumping should be allocated in areas to assure full capture of the flux of water from and under the tailings. Based on this evaluation, the need for modification to the treatment plant and the true need for evaporative capacity should be further considered.

10 REFERENCES

Environmental Quality Management, (2008) Draft Final Remediation System Evaluation, Homestake Superfund Site, Grants, NM, December 19, 2008

Federal Remediation Technology Roundtable (FRTR, 2002) "Evaluation of Permeable Reactive Barrier Performance", prepared by the Tri-Agency Permeable Reactive Barrier Initiative, December 2002.

Fryxell, G.E., et al., (2005), Environ. Sci. Technol., 39, 1324-1331.

Hochstein, Ron F., Rod Warner, and Terry Wetz, 2003. Transportation of the Moab Uranium Mill Tailings to White Mesa Mill by Slurry Pipeline, Proceedings, WM '03 Conference, Tucson, 23-27 February 2003.

Homestake Mining Company, (HMC, 2009a), 2008 Annual Monitoring Report/Performance Review for Homestake's Grants Project, March 2009.

Homestake Mining Company, (HMC, 2009b), HMC Presentation (and related discussion) to RSE Addendum Stakeholders and USACE team, April 2009.

Homestake Mining Company (HMC, 2009c), Treatment Plant Data (Sept 2009) supplied directly from Homestake Mining Company records to the USACE, response to 19 September 2009 Homestake/USACE teleconference.

Homestake Mining Company (HMC, 2010a), Homestake and USACE teleconference, 22 January 2010.

Homestake Mining Company, (HMC, 2010b), "Treatment Alternatives Testing in the Large Tailing Pile", Letter from Homestake Mining Company (Alan D. Cox) to John T. Buckley, U.S. Nuclear Regulatory Commission, 13 August 2010 .

Hydro-Engineering LLC, (2006), Ground Water Modeling for Homestake's Grants Project, April, 2006, Appendix C to Groundwater Corrective Action Program Revision, December, 2006.

Interstate Technology and Regulatory Council (ITRC), (2007), Technical Regulatory Document on "Protocol for Use of Five Passive Samplers to Sample for a Variety of Contaminants in Groundwater"

ITRC (in press), Technical Regulatory Document on "Remediation Risk Management"

Remediation Technologies Development Forum (RTDF), (2001), RTDF Permeable Reactive Barrier Action Item, May 24, 2001, http://www.rtdf.org/PUBLIC/PERMBARR/prbsumms/profile.cfm?mid=47.

SERDP (2000) “Design Guidance for Application of Permeable Reactive Barriers for Groundwater Remediation”, prepared by Battelle, Inc. 31 March 2000.

Shearer, Jr., S.D. and Sill, C.W., (1969), “Evaluation of Atmospheric Radon in the Vicinity of Uranium Mill Tailings”, Health Physics Vol. 17, pp. 77-88.

Skiff and Turner, (1981), Alkaline Carbonate Leaching at Homestake Mining Co., paper provided by HMC, published in 1981

US Environmental Protection Agency (EPA) and US Geological Survey (2000) “Field Demonstration of Permeable Reactive Barriers to Remove Dissolved Uranium from Groundwater, Frye Canyon, Utah, September 1997 through September 1998 Interim Report, EPA 402-C-00-001, November 2000

US EPA/USACE, (2005), Roadmap to Long-Term Monitoring Optimization (EPA 542-R-05-003, 2005, available at http://www.frtr.gov/optimization/monitoring/ltm.htm)

US EPA (2008), EPA 402-R-08-005, Technical Report on Technologically Enhanced Naturally Occurring Radioactive Materials from Uranium Mining, 2008

Wellman, D.M. (2007), et al., Environ. Chem. 2007, 4, 293-300.

APPENDIX A – RSE ADDENDUM SCOPE OF WORK

Scope of Work

Final 8/20/09

US Army Corps of Engineers Environmental and Munitions Center of Expertise
Focused Review of Specific Remediation Issues
Homestake Mining Company (Grants) Superfund Site, New Mexico

Based on discussions between the US Environmental Protection Agency (USEPA) and the New Mexico Environmental Department (NMED), interested stakeholder groups, and Homestake Mining/Barrick Gold, the following tasks will be performed by the US Army Corps of Engineers (USACE) Environmental and Munitions Center of Expertise (EM CX) to supplement past Remediation System Evaluation work at the site. In general, the review is intended to provide a critical review of the current remedial ground water strategy, including whether other approaches or technologies could be incorporated that may be more efficient and/or effective at achieving site closure goals. The outcome will be a summary of any recommended modifications necessary to improve performance or overcome performance deficiencies, or that would potentially reduce life-cycle costs or time to achievement of remedial goals. The analysis will not address the issues regarding the site background levels or specified cleanup goals. Specifically, the USACE EM CX would:

1) Evaluate the adequacy of plume capture, horizontally and vertically, of the ground water plumes in the alluvial and Chinle aquifers, using the recent EPA guidance on capture analysis (EPA, 2007) as a guide. The conceptual model of ground water flow and contaminant transport in the natural aquifers would be evaluated and refined. No ground water modeling will be conducted as part of the analysis, though a limited assessment of the approach to ground water modeling conducted by Homestake will be performed. As part of the evaluation, the effects of and alternatives to specific components of the current remedial strategy including: a) pumping/injection in the Chinle and alluvial aquifers, b) diversion of ground water upgradient of the large tailing pile (LTP), c) use of clean/treated water injection, and d) irrigating with untreated water in downgradient areas would be evaluated. Capture analysis would be conducted using analytical groundwater equations, preparation and analysis of piezometric maps, graphs of contaminant concentrations in specific monitoring and production wells, and professional judgment. Heterogeneity (e.g., channels, faults, etc.) in the subsurface pathways, a range of site and climatic conditions, and site geochemistry will be considered. The potential impacts from site conditions on the San Andres aquifer will be addressed to the extent possible with existing information. Potential human health issues surrounding the current irrigation practices would be assessed and alternatives to current practices would be conceptually developed. Alternatives to current practices that may be considered include, for example, different pumping and injection locations, in-situ immobilization, passive treatment, deep-well injection, or other technologies. The analysis will identify: areas where certainty of capture is low, recommendations for further investigations, suggested alternative extraction/injection operational strategies, necessary pilot testing, and, where possible, conceptual designs/descriptions of alternatives. The evaluation will also address to the extent possible the likelihood that the ground water restoration efforts will achieve performance objectives by the end of 2017. No detailed designs or rigorous cost estimates would be prepared. The report will

include a brief description of the conceptual model developed as part of the analysis. Detailed descriptions of the site conditions will not be provided, though references for such information will be cited.

2) Evaluate the overall strategy (including cost-effectiveness and protectiveness) of flushing contaminants from the LTP and discharging contaminants to evaporation ponds for eventual long-term entombment and to assess alternative remedial strategies. The analysis will include the critical evaluation of the current conceptual model for flushing, geochemical changes, heterogeneity, and evaluation of mass balance for water injected and recovered from the toe drains, LTP extraction wells, and downgradient extraction wells. The use of similar flushing approaches and the observed performance for such applications will be researched. Alternatives to the current strategy (e.g., slurry walls, immobilization, etc.) that would achieve the intended goal of restricting future contaminant mass flux to the underlying aquifers would be conceptually developed. The rough costs for such alternatives would be compared to a rough estimate of the costs, risks, and environmental impacts of fully removing the tailings from the site. The ability to monitor for leakage from the ponds will also be assessed through a qualitative review of the monitoring well network in the vicinity of the ponds and an assessment of inspection and repair methods. The results of the analysis would include a brief critique of the current LTP conceptual model, descriptions and rough costs for any promising alternatives to the current site actions at the LTP, and the assessment of the leakage from the ponds. These would be documented in the report. No detailed designs or rigorous cost estimates would be prepared.

3) Assess potential modifications to the reverse osmosis (RO) units and related treatment components to achieve full capacity operations of the treatment plant. The analysis would include development of conceptual designs for modifications to the existing plant or addition of new equipment or alternative treatment processes to improve plant effectiveness, throughput, and cost efficiency. These proposed modifications would be developed in conjunction with the overall strategy for capture of site plumes and management of the tailings piles. The role that increased RO system treatment capacity would potentially play in alternative remedial strategies will be assessed. The recommended changes or additions would be conceptually described in the report and accompanied by rough cost estimates. No detailed designs or rigorous cost estimates would be prepared.

4) Evaluate the projected evaporation rates for the new and existing ponds. This would include independent calculation of lake evaporation considering salinity of the water in the ponds, an evaluation of the need for spray evaporation enhancements with the addition of the proposed [permitted?] evaporation pond 3, and an evaluation of alternatives to spray evaporation enhancements. The impact on the necessary evaporation rates due to alternative strategies for treating extracted water (or changes in the flow rates to the ponds as a result of the analysis of the capture adequacy) would be considered in comparing evaporative capacity to what is needed. Calculations, explanations, and recommendations, if any, will be provided in the report.

5) Assess the monitoring network for sufficiency (both laterally, vertically) and possible redundancies, as well as to determine appropriate sampling frequency. The analysis of ground water monitoring would be conducted using a non-quantitative approach that considers:

- the rate of contaminant transport, including behavior of the different chemical species
- previously observed variability in contaminant concentrations,
- historical trends in concentrations,
- frequency of routine data analysis by interested stakeholders,
- location of monitoring wells to potential receptors,
- locations of monitoring wells relative to other monitoring wells, and
- the time available to modify the remedy based on evidence of any unexpected plume migration.

The recommended frequency and locations could be based on any or all of these considerations. The results of the analysis would be tabulated in tables, maps, and/or text in the report. The conclusions may include identification of areas possibly requiring additional monitoring points, general sampling frequency recommendations for wells in different parts of the site/plume, specific recommendations for sampling frequency in certain wells, and possibly redundant monitoring wells. The report may also make recommendations for sampling and analytical methods, data management, and reporting requirements. The report may recommend a more detailed quantitative analysis using more sophisticated software.

The current air monitoring program will also be critically evaluated regarding sampling location, methods, analyses, frequency, and interpretation of results. The report will provide recommendations, as appropriate, regarding these aspects of the air monitoring program.

6) Evaluate the appropriateness of the current practice of irrigating with untreated water, particularly in light of the new NMED and EPA water quality standard for uranium (0.03 mg/L). The analysis may include considerations of alternative operational strategies, necessary additional monitoring or modification to the monitoring approach, potential impact of recharge on ground water flow, and/or modifications to the current approach to addressing downgradient portions of the contaminant plumes (including treatment). The conclusions and recommendations will be documented in the report.

7) Qualitatively assess the small tailings pile (STP) as a potential source of ground water contamination and need, if any, for ultimate capping of the STP beyond the planned radon barrier. This assessment would primarily involve determination of historical ground water concentration trends for wells around the STP and the assessment of the means to assess leakage, if any, from Pond 1, as discussed in item 2 above. The results of the assessment would be documented in the report text supported by various figures, if appropriate.

APPENDIX B – COMMUNICATIONS PLAN

Remediation System Evaluation (RSE)
Advisory Group and Communication Plan for the
Homestake Mining Company Superfund Site

<u>Goals of the RSE Advisory Group and Communication Plan</u>: The goals of the RSE Advisory group are to provide an opportunity for citizens, the responsible party (RP), and other interested stakeholders to interact with EPA in the development of the scope for the follow-on RSE, to provide pertinent site background information that will be useful in preparation of the RSE, to review draft and final RSE reports, and to provide a direct communication channel to EPA and the regulatory agencies involved in preparing the RSE. The goal of the communication plan is to document the communication strategy between individuals preparing the RSE, the RSE Advisory Group, and the regulatory agencies.

<u>RSE Advisory Group Members</u>: RSE Advisory Group members will consist of a subset of concerned citizens, technical advisors that support citizen interests, the site owner and site owner representatives, regulatory personnel, and individuals performing the follow-on RSE. The following table provides a list of proposed RSE Advisory Group members:

RSE Advisory Group Members

Name	Affiliation	Email Address	Phone Number (optional)
Candace Head-Dylla	Citizen cuh148@psu.edu		505-404-4349
Milton Head	BVDA	miltonhead@gmail.com	505-287-3496
Art Gebeau	BVDA	gebeau@7cities.net	505-287-3613
Laura Watchempino	Water Quality Specialist, Pueblo of Acoma	haakuwater@yahoo.com	505-552-6604 x5547
Richard Abitz	Technical Support contractor to BVDA	rabitz@cinci.rr.com	513-226-5329
Paul Robinson	Southwest Research Information Center, Advisor to Pueblo of Acoma	sricpaul@earthlink.net	505-262-1862
Chris Shuey	Southwest Research Information Center, Advisor to Pueblo of Acoma	sric.chris@earthlink.net	505-262-1862
Al Cox	Homestake Mining Company of California	acox@barrick.com	505-400-2794
George Hoffman	HydroEngineering	hydro@alluretech.net	
Rocky Chase	Homestake Mining Company of California	rchase@barrick.com	801-990-3747
Kathy Yager	U.S. EPA Office of	yager.kathleen@epa.gov	617-918-8362

	Superfund Remediation and Technology Innovation		
Sai Appaji	U.S. EPA Region 6	appaji.sairam@epa.gov	214-665-3126
Donn Walters	U.S. EPA Region 6	walters.donn@epa.gov	214-665-6483
Robert Ford	U.S. EPA National Risk Management Research Laboratory	ford.rober@epa.gov	513-569-7501
Jerry Schoeppner	New Mexico Environment Department	jerry.schoeppner@state.nm.us	505-827-0652
David Mayerson	New Mexico Environment Department	david.mayerson@state.nm.us	505-476-3777
John Buckley	Nuclear Regulatory Commission	John.Buckley@nrc.gov	301-415-6607
David Becker	RSE Team	dave.j.becker@usace.army.mil	402-697-2655
Carol Dona	RSE Team	carol.l.dona@usace.army.mil	402-697-2582
Brian Hearty	RSE Team	brian.p.hearty@usace.army.mil	402-697-2478

Communication Plan: The primary form of communication will be through conference calls, the internet, and email. Due to time and cost considerations, in person meetings will be kept to a minimum. All individuals listed on the RSE Advisory Group will be included in all email correspondence and invited to participate in all conference calls.

Proposed Conference Calls

1. RSE Advisory Group and Communication Plan Discussion: Purpose – to discuss the draft RSE Advisory Group and Communication Plan
2. Scope of Work Discussion 1. Purpose - to discuss revised draft SOW for the USACE and finalize the RSE Advisory Group and Communication Plan
3. Scope of Work Discussion 2. Purpose - to discuss the final USACE SOW
4. Progress Report. Purpose - for EPA and USACE to report out on progress and preliminary findings of the follow-on RSE and solicit input from the RSE Advisory Group
5. Draft Report. Purpose – to discuss the draft Follow-on RSE report and RSE Advisory Group Comments
6. Final Report – Purpose – to discuss RSE Advisory Group report comments, response to comments, and changes to the draft Follow-on RSE report
7. Others as necessary

Timing of Conference Calls: It is proposed that conference calls be held at 12:00 noon Mountain Time to accommodate individual work schedules, however the call schedule may change based on future needs

Posting of Information: All information related to the Follow-on RSE, the RSE Advisory Group, and the Communication Plan will be posted on an internet site hosted by EPA referred to as the Homestake Mining Company Lotus Notes Quick Place Site. User access will be provided to all RSE Advisory Group members and other key contacts listed above. Each member will be responsible for signing up to set up an individual username and password.

https://epaqpx.rtp.epa.gov/QuickPlace/homestake/Main.nsf?OpenDatabase

Types of information to be posted on the Quick Place Site:

1. All documents reviewed as part of the Follow-on RSE
2. The RSE Advisory Group Communication Plan
3. Draft and final reports

Individual Communications: All individual communications between a RSE Team and a member of the RSE Advisory Group shall be summarized in written format by the RSE Team Member and posted on the Quick Place Site under a subsection called "Individual Communication". The purpose of this documentation is to ensure that all information communicated to the RSE Team is also communicated to all members of the RSE Advisory Group.

APPENDIX C - OUTPUT FROM SUSTAINABLE REMEDIATION TOOL

SRT Input Current Pump&Treat System

PUMP AND TREAT - TIER 2

Homestake Mining Superfund
Grants, NM
CAPITAL and O&M

Instructions:
- (white box) = Enter your data here. Click button to the right of the cell for help.
- (light gray box) = Use this default value or override with your own.
- (dark gray box) = Calculated value. You cannot change this.

Restore Defaults

Recommended flow: Main → Input → Technology Design (You are here) → Results

Technology Design:
- [x] Pump & Treat
- [ ] Enhanced Bioremediation
- [ ] In Situ Chemical Oxidation
- [x] PRB
- [ ] LTM / MNA

Design for Managing Groundwater

Airline miles flown by project team (total miles for all travelers)		miles over proj lifetime
Average Distance Traveled by Site Workers per one-way trip	5	miles one-way
Trips by Site Workers during construction	0	# over project lifetime
Trips by Site Workers after construction	44000	# over project lifetime
Remediation Design (Purpose)	Containment	
Duration (must be <100 years)	50	years
Total pumping rate	450.	gpm
Number of wells	60.	#
Length of manifold	0.	ft
Treatment Method	Activated Carbon	
Beginning Plume Mass	11,000.	kg
Ending Plume Mass	11,000.	kg

Tier 2: Change Calculated Values (dark gray boxes)

	Original Plume		After Project	
Plume Area	1,200.	acres	1,200.	acres
Plume Length	10,000.	feet	10,000.	feet
Plume Volume	3,300.	million gallons	3,300.	mil gals
Dissolved Mass	11,000.	kg	11,000.	kg

Materials and Consumable Amounts Used for Metrics

PVC	0.	lbs
Steel	0.	lbs
Activated carbon	46.	lbs
Electricity	120,000,000.	kWh
Diesel (Capital)	0.	gal
Diesel (O&M)	0.	gal
Gasoline (Capital)	0.	gal
Gasoline (O&M)	29,334.	gal
Natural gas	0.	mcf

Technology Cost

Capital	4,100,000.	$
O&M	34,000,000.	$ over project

Project-specific Metrics (Add & Subtract/Offsets)?

Yes / No

Additional Technology Cost		$
Total Energy Consumed		Megajoules
CO_2 Emissions to Atmosphere		tons CO_2
Safety / Accident Risk		lost hours

Design Calculations - Pump & Treat

Total pumping rate - Containment	450.	gpm	Containment pumping rate (capture zone equation): Maximum plume width * Hydraulic conductivity * Aquifer thickness * Gradient * 2 * unit conversions.
Plume volume	437,500,000.	ft3	Remediation pumping rate (assumes 1 pore volume per year): Total plume volume for all zones * unit conversions.
Total pumping rate - Remediation	450.	gpm	
Total pumping rate - initial estimate	450.	gpm	
Number of wells per acre	0.05		
Plume area	1200	acres	
Number of wells	60.	#	Number of wells: Number of wells per acre * Number of acres
Per well pump rate	7.5	gpm	Initial estimated total pump rate / number of wells
Adjusted per well pump rate	7.5	gpm	Adjust for pump sizes
Adjusted total pump rate	450	gpm	Re-calculated based on number of wells * adjusted per well pump rate
Length of manifold	0.	ft	Length of PVC for manifold: Total length of each zone + Number of wells * Maximum plume width / 4
Treatment method	Activated Carbon		Treatment method entered above. If maximum concentrations is less than 1 mg/L, then activated carbon is the default value. Otherwise, air stripper is selected. This default value can be modified in the summary above.
Beginning plume mass	11,000.	kg	Beginning plume mass: The sum of each zone of Area of Doughnut * Aquifer thickness & porosity * representative concentration * unit conversions.
Operating time	8,320.	hrs/yr	Operating time: the hours per year the system is in operation.
Pore volumes recovered	3.4	#	Pore volumes recovered: Pump rate * Duration * unit conversions / original plume volume. This factor is used to calculate the concentration reduction factor (CRF): If pore volumes recovered < 3, CRF = (-0.2195* PVr) + 1. If pore volumes recovered >=3, CRF = 1.3367 * PVr ^(-1.2424). Minimum CRF = 0.05. For Containment systems, CRF = 1.
Concentration reduction factor	1.		
Adjusted CRF	1.		
Ending plume mass	11,000.	kg	Ending plume mass: See PlumeCalcs worksheet for calculation based on original plume dimensions and CRF. For Containment systems, the starting and ending mass is assumed to be the same.

Materials and Consumable Calculations - Pump & Treat

Length of PVC per well	0.	ft	Length of PVC per well: default value is depth to groundwater + aquifer thickness.
Additional PVC pipe	0.	ft	Additional PVC pipe: optional amount of PVC in the Pump and Treat system.
Length of PVC for manifold (from above)	0.	ft	
Conversion factor	2.03	lbs/ft	
PVC	0.	lbs	Amount of PVC: [PVC per well * number of wells + additional PVC pipe + PVC for manifold] * conversion factor. This value is calculated for Capital or both Capital and O&M projects.
Length of Steel Pipe per well	0.	ft/well	Length of steel pipe per well includes well screen.
Conversion factor	10.79	lbs/ft	Conversion factor for weight of steel pipe.
Other steel per well	0.	lbs	Other steel per well includes equipment such as pumps.
Other steel (system-wide, eg, treatment system	0.	lbs	Other steel for system includes weight of air stripper or carbon tanks.
Steel	0.	lbs	Amount of steel: [Steel pipe per well * number of wells * conversion factor + Other steel per well * number of wells + other system components]. This value is calculated for Capital or both Capital and O&M projects.
Operating time	8,320.	hrs/yr	Amount of activated carbon, if required by treatment system, is based on average concentration in recovered groundwater (a function of pump rate, operating time and duration), and contaminant-specific parameters from Dobbs and Cohen, 1980. This value is calculated for O&M and both Capital and O&M projects.
Average concentration	0.0001	mg/L	
K parameter	28.		
1/n parameter	0.62		
Activated carbon	46.	lbs	
Power requirements	300.	kW per hr	Amount of electricity over project lifetime: Power requirements * Operating time in hours / year * Duration (input above). This value is calculated for O&M and both Capital and O&M projects.
Operating time	8,320.	hrs/yr	
Electricity	120,000,000.	kWh	

Linear feet for trenching	0.	*ft*	Amount of diesel is based on the amount of fuel for trenching plus drilling. Diesel is calculated for Capital and both Capital and O&M projects.
Trenching rate	300.	*ft/hr*	
Trenching fuel consumption rate	0.	*gal/hr*	
Fuel for trenching	0.	*gal*	
Linear feet for drilling	0.	*ft*	
Drilling rate	100.	*ft/day*	
Drilling fuel consumption rate	0.	*gal/day*	
Fuel for drilling	0.	*gal*	
Total fuel (diesel; capital phase)	0.	*gal*	
Vehicle mileage (transportation for activated carbon disposal)	5.	*mpg*	Diesel for O&M is calculated based on transport for activated carbon.
Miles traveled for activated carbon disposal (O&M)	0.	*miles (project total)*	
Diesel (O&M phase)	0.	*gal*	

Jet fuel use rate per passenger	0.0000097	*gal/mi*	Total jet fuel: Jet fuel use rate * weight * air miles input above. The default calculation assumes 50% is used in capital, and 50% used in O&M phases.
Weight of passenger + luggage	200.	*lbs*	
Total air miles (all passengers; input above)	0.	*miles*	
Jet fuel (capital phase)	0.	*gal*	
Jet fuel (O&M phase)	0.	*gal*	
Vehicle mileage (travel)	15.	*mpg*	
Miles traveled (capital)	0.	*miles*	
Gasoline (capital)	0.	*gal*	
Vehicle mileage (travel)	15.	*mpg*	
Miles traveled (O&M)	440,000.	*miles*	
Gasoline (O&M phase)	29,334.	*gal*	
Total fuel (gasoline + jet fuel) - Capital phase	0.	*gal*	
Total fuel (gasoline + jet fuel) - O&M phase	29,334.	*gal*	

Natural gas requirements for PT/Therm Ox

Operation Time	8,320.	*hrs/yr*	If treatment method is Air Stripper/Therm Ox, amount of natural gas: Natural gas flow rate * Duration (input above) * Operation time in hours per year * unit conversions.
Natural gas flow rate	2.21	*scfm*	
Natural gas for Therm Ox	0.	*mcf*	

Natural gas requirements for Activated Carbon regeneration

Conversion factor	0.	*btu/lb activated carbon*	If treatment method is Activated Carbon, amount of natural gas: Amount of activated carbon (calculated above) * conversion factor.
Natural gas for activated carbon	0.	*mcf*	
Natural gas used for metrics (Therm Ox or Activated Carbon)	0.	*mcf*	Natural gas is used in metrics calculations for O&M and both Capital and O&M projects.

Metrics - Baseline Calculations

Technology Cost

Volume recovered	220,000.	*1,000 gal/yr*	Capital and O&M Costs are based on site data from USEPA 2001. Capital cost = [277189 * Volume ^ (-0.781)] * Volume. Annual O&M cost = [40500 * Volume ^ (-0.7706)] * Volume.
Technology Cost (Capital)	4,100,000.	*$*	
Technology Cost (O&M)	680,000.	*$/year*	
Technology Cost (O&M)	34,000,000.	*$ over project*	

Energy Cost - Modify usage in Materials and Consumables (above). Update costs on Conversion tab

Safety/Accident Risk

Hours worked (Capital)	26,000.	*hrs*	Safety/Accident Risk: (Statistical number of injuries from time worked + injuries from miles traveled) * lost hours per injury.
Vehicle speed	40.	*mph*	
Hours worked (O&M)	660,000.	*hrs*	
Total hours worked	686,000.	*hrs*	
Injuries per hour	2.74E-09	*injuries/hr*	
Vehicle miles traveled (Capital)	0.	*miles*	
Vehicle miles traveled (O&M)	440,000.	*miles*	
Total vehicle miles traveled	440,000.	*miles*	
Injuries per mile	9.10E-07	*injuries/mi*	
Lost hours per injury	48.	*hrs/injury*	
Safety/Accident Risk	19.	*lost hours*	

SRT Input, Slurry Wall

PERMEABLE REACTIVE BARRIER - TIER 2
Homestake Mining Superfund
Grants, NM
CAPITAL and O&M

Instructions:
= Enter your data here. Click button to the right of the cell for help.
= Use this default value or override with your own.
= Calculated value. You cannot change this.
Restore Defaults

Recommended flow:
Main → Input → Technology Design (Pump & Treat, Enhanced Bioremediation, In Situ Chemical Oxidation, PRB, LTM / MNA) → Results
You are here

Design for Managing Groundwater

Airline miles flown by project team (total miles for all travelers)		*miles over proj lifetime*
Average Distance Traveled by Site Workers per one-way trip	5	*miles one-way*
Trips by Site Workers during construction	260	*# over project lifetime*
Trips by Site Workers after construction		*# over project lifetime*
Remediation design (Purpose)	Containment	
Wall type	Mulch	
Depth of wall	80	*ft*
Total length of wall	13000	*ft*
Average COC concentration upgradient of wall	30.	*mg/L*
Disposal type	Non-hazardous	
Remediation duration	75	*years*

Tier 2: Change Calculated Values (dark gray cells)

	Original Plume		After Project	
Plume Area	1,200.	*acres*	1,100.	*acres*
Plume Length	10,000.	*feet*	9,000.	*feet*
Plume Volume	3,200.	*mil gals*	2,900.	*mil gals*
Dissolved Mass	11,000.	*kg*	9,900.	*kg*

Materials and Consumable Amounts Used for Metrics

PVC	0.	*lbs*	
Diesel (Capital)	28,000.	*gal*	
Diesel (O&M)	150,000.	*gal*	
Gasoline (Capital)	170.	*gal*	
Gasoline (O&M)	0.	*gal*	
Mulch	15,000.	*cu yd*	*Not used in metrics*
Substrate	23,400,000.	*lbs*	

Technology Cost

Capital	17,000,000.	*$*
O&M	62,000,000.	*$ over project*

Project-specific Metrics (Add & Subtract/Offsets)

Yes No

Additional Technology Cost		*$*
Total Energy Consumed		*Megajoules*
CO_2 Emissions to Atmosphere		*tons* CO_2
Safety / Accident Risk		*lost hours*

Design Calculations - Permeable Reactive Barrier

Restore Defaults (Detail Section)

Average COC concentration upgradient of wall	30.	*mg/L*	Original plume mass divided by plume volume, converted to mg/L.
Seepage velocity	330.	*ft/year*	Seepage velocity is calculated on InputGW tab.
Depth of wall	80.	*ft*	Entered above.
Total length of wall	13,000.	*ft*	For Source Remediation, the default is the width of Plume Zone 1 (entered on InputGW tab). Otherwise, the default is the maximum plume width of all zones entered on the InputGW tab. Wall thickness is based on the type of wall, average COC concentration upgradient of the wall, and seepage velocity. Mulch walls range from 2 to 6 feet thick; ZVI walls range from 2 to 4 ft.
Wall thickness	2.	*ft*	
Volume (total)	77,000.	*cu yd*	Depth * total length * thickness, divided by 27 to convert to cubic yards.
Depth to water	50.	*ft*	Depth of wall must be greater than the depth to water. Edit depth to water on InputGW tab.
Volume below water	29,000.	*cu yd*	
Composition ratio	50%	*gravel*	Composition is based on type of wall, average COC concentration upgradient of the wall, and seepage velocity.
	50%	*mulch*	
Volume of gravel	15,000.	*cu yd*	Volume below water * composition ratio.
Volume of mulch	15,000.	*cu yd*	
Dump truck volume	12.	*cu yd*	
Fluff factor (gravel or sand)	1.3	-	
Number of loads for gravel (or sand)	1,625.	*# loads*	Volume of gravel or sand * fluff factor, divided by dump truck volume.
Fluff factor (mulch or iron)	1.3	-	
Number of loads for mulch (or iron)	1,625.	*# loads*	Volume of mulch or iron * fluff factor, divided by dump truck volume.
Distance from site to gravel/sand/mulch source	20.	*miles one-way*	
Total miles driven	130,000.	*miles*	
Distance from site to iron source (ZVI)	1,000.	*miles one-way*	
Total miles driven	0.	*miles*	
Trenching rate	200.	*ft/day*	
Hours to install wall (trenching)	1,600.	*hrs*	Wall length divided by trenching rate, multiplied by 24 (to convert to hours).
Spread/compaction rate	654.	*cu yd/hr*	
Fluff factor	1.3	-	
Hours to install wall (loading/fill)	95.	*hrs*	
Volume of trench spoils (for disposal)	29,000.	*cu yd*	
Fluff factor	1.3	-	
Dump truck volume	12.	*cu yd*	
Loads for disposal	3,142.	#	
Distance to disposal	1.	*miles one-way*	
Miles driven for disposal	6,284.	*miles*	

Materials and Consumable Calculations - Permeable Reactive Barrier

Length of PVC per well	80.	*ft*	
Number of monitoring points	0.	#	Default number of monitoring points assumes 1 transect (3 wells) per 200 feet of wall.
Conversion factor	0.	*lbs/ft*	
PVC	0.	*lbs*	PVC includes two pipes (upper and lower) installed in wall for substrate recharge during O&M phase.
Substrate (O&M)	23,400,000.	*lbs*	Substrate for recharge / rejuventation of wall. Assumed every 5 years.
Linear feet for drilling	0.	*ft*	Default assumes wall depth * number of monitoring points.
Drilling rate	100.	*ft/day*	
Drilling fuel consumption rate	32.	*gal/day*	
Fuel for drilling (diesel)	0.	*gal*	Linear feet for drilling divided by drilling rate, multiplied by fuel consumption rate.
Fuel consumption rate, trencher	6.25	*gal/hr*	
Fuel for trenching (diesel)	10,000.	*gal*	Default is calculated by the hours to install wall (trenching) * fuel consumption rate.
Fuel consumption rate, loader	10.	*gal/hr*	
Fuel for loading/fill (diesel)	950.	*gal*	Defaults is calculated by the hours to install wall (loading/fill) * fuel consumption rate.
Fuel consumption rate, delivery and disposal	8.	*mpg*	
Total miles	136,284.	*miles*	Total miles includes miles driven to deliver sand/iron or gravel/mulch, and disposal.
Fuel for delivery/disposal	17,000.	*gal*	
Total fuel (Diesel, Capital)	28,000.	*gal*	Total Capital diesel is fuel for bringing in materials, wall installation, and disposal of spoils.
Total fuel (Diesel, O&M)	150,000.	*gal*	Total O&M diesel is fuel for transporting substrate for recharge of wall.
Jet fuel use rate per passenger	0.0000097	*gal/mi*	Total jet fuel: Jet fuel use rate * weight * air miles input above.
Weight of passenger + luggage	200.	*lbs*	
Total air miles (all passengers; input above)	0.	*miles*	
Jet fuel (Capital)	0.	*gal*	
Jet fuel (O&M)	0.	*gal*	
Vehicle mileage (travel)	15.	*mpg*	
Miles traveled (Capital)	2,600.	*miles*	Default calculation is based on one-way distance to site * 2 * number of trips (construction)
Gasoline (Capital)	174.	*gal*	Default calculation is number of miles traveled, divided by vehicle mileage.
Vehicle mileage (travel)	15.	*mpg*	
Miles traveled (O&M)	0.	*miles*	Default calculation is based on one-way distance to site * 2 * number of trips (post construction)
Gasoline (O&M)	0.	*gal*	Default calculation is number of miles traveled, divided by vehicle mileage.
Total fuel (gasoline + jet fuel) (Capital)	170.	*gal*	
Total fuel (gasoline + jet fuel) (O&M)	0.	*gal*	

Metrics - Basic Calculations

Technology Cost

Wall area	1,040,000.	*ft2*
Unit cost (Capital) - Hazardous	0.	*$/ft2*

Technology Cost (Capital) - Hazardous	0.	$
Unit cost (O&M) - Hazardous	0.	$/ft2
Technology Cost (O&M) - Hazardous	0.	$
Unit cost (Capital) - Non-hazardous	16.	$/ft2
Technology Cost (Capital) - Non-hazardous	17,000,000.	$
Unit cost (O&M) - Non-hazardous	4.	$/ft2
Technology Cost (O&M) - Non-hazardous	62,000,000.	$
Cost (Capital)	17,000,000.	$
Cost (O&M)	62,000,000.	$

Energy Cost - Energy usage can be modified in Materials and Consumables (above). Update costs on Conversion ta

Safety/Accident Risk

Vehicle speed	40.	*mph*
Hours worked (Capital)	110,000.	*hrs*
Hours worked (O&M)	400,000.	*hrs*
Total hours worked	510,000.	*hrs*
Injuries per hour	2.74E-09	*injuries/hr*
Vehicle miles traveled (Capital)	2,600.	*miles*
Vehicle miles traveled (O&M)	18,000,000.	*miles*
Total vehicle miles traveled	18,002,600.	*miles*
Injuries per mile	9.10E-07	*injuries/mi*
Lost hours per injury	48.	*hrs/injury*
Safety/Accident Risk	790.	*lost hours*

Safety/Accident Risk: (Statistical number of injuries from time worked + injuries from miles traveled) * lost hours per injury.

SRT Input, Reduced Pump&Treat

PUMP AND TREAT - TIER 2
Homestake Mining Superfund
Grants, NM
CAPITAL and O&M

Instructions:
= Enter your data here. Click button to the right of the cell for help.
= Use this default value or override with your own.
= Calculated value. You cannot change this.
Restore Defaults

Recommended flow:
Main → Input → Technology Design → Results
Technology Design — You are here
- Pump & Treat
- Enhanced Bioremediation
- In Situ Chemical Oxidation
- PRB
- LTM / MNA

Design for Managing Groundwater

Airline miles flown by project team (total miles for all travelers)		miles over proj lifetime
Average Distance Traveled by Site Workers per one-way trip	5	miles one-way
Trips by Site Workers during construction	0	# over project lifetime
Trips by Site Workers after construction	49500	# over project lifetime
Remediation Design (Purpose)	Containment	
Duration (must be <100 years)	75	years
Total pumping rate	450.	gpm
Number of wells	60.	#
Length of manifold	0.	ft
Treatment Method	Activated Carbon	
Beginning Plume Mass	11,000.	kg
Ending Plume Mass	11,000.	kg

Tier 2: Change Calculated Values (dark gray boxes)

	Original Plume		After Project	
Plume Area	1,200.	acres	1,200.	acres
Plume Length	10,000.	feet	10,000.	feet
Plume Volume	3,300.	million gallons	3,300.	mil gals
Dissolved Mass	11,000.	kg	11,000.	kg

Materials and Consumable Amounts Used for Metrics

PVC	0.	lbs
Steel	0.	lbs
Activated carbon	69.	lbs
Electricity	31,000,000.	kWh
Diesel (Capital)	0.	gal
Diesel (O&M)	0.	gal
Gasoline (Capital)	0.	gal
Gasoline (O&M)	33,334.	gal
Natural gas	0.	mcf

Technology Cost

Capital	4,100,000.	$
O&M	51,000,000.	$ over project

Project-specific Metrics (Add & Subtract/Offsets)?

Yes No

Additional Technology Cost		$
Total Energy Consumed		Megajoules
CO_2 Emissions to Atmosphere		tons CO_2
Safety / Accident Risk		lost hours

Design Calculations - Pump & Treat

Total pumping rate - Containment	450.	gpm	Containment pumping rate (capture zone equation): Maximum plume width * Hydraulic conductivity * Aquifer thickness * Gradient * 2 * unit conversions.
Plume volume	437,500,000.	ft3	Remediation pumping rate (assumes 1 pore volume per year): Total plume volume for all zones * unit conversions.
Total pumping rate - Remediation	450.	gpm	
Total pumping rate - initial estimate	450.	gpm	
Number of wells per acre	0.05		
Plume area	1200	acres	
Number of wells	60.	#	Number of wells: Number of wells per acre * Number of acres
Per well pump rate	7.5	gpm	Initial estimated total pump rate / number of wells
Adjusted per well pump rate	7.5	gpm	Adjust for pump sizes
Adjusted total pump rate	450	gpm	Re-calculated based on number of wells * adjusted per well pump rate
Length of manifold	0.	ft	Length of PVC for manifold: Total length of each zone + Number of wells * Maximum plume width / 4
Treatment method	Activated Carbon		Treatment method entered above. If maximum concentrations is less than 1 mg/L, then activated carbon is the default value. Otherwise, air stripper is selected. This default value can be modified in the summary above.
Beginning plume mass	11,000.	kg	Beginning plume mass: The sum of each zone of Area of Doughnut * Aquifer thickness & porosity * representative concentration * unit conversions.
Operating time	8,320.	hrs/yr	Operating time: the hours per year the system is in operation.
Pore volumes recovered	5.1	#	Pore volumes recovered: Pump rate * Duration * unit conversions / original plume volume. This factor is used to calculate the concentration reduction factor (CRF): If pore volumes recovered < 3, CRF = (-0.2195* PVr) + 1. If pore volumes recovered >=3, CRF = 1.3367 * PVr ^(-1.2424). Minimum CRF = 0.05. For Containment systems, CRF = 1.
Concentration reduction factor	1.		
Adjusted CRF	1.		
Ending plume mass	11,000.	kg	Ending plume mass: See PlumeCalcs worksheet for calculation based on original plume dimensions and CRF. For Containment systems, the starting and ending mass is assumed to be the same.

Materials and Consumable Calculations - Pump & Treat

Length of PVC per well	0.	ft	Length of PVC per well: default value is depth to groundwater + aquifer thickness.
Additional PVC pipe	0.	ft	Additional PVC pipe: optional amount of PVC in the Pump and Treat system.
Length of PVC for manifold (from above)	0.	ft	
Conversion factor	2.03	lbs/ft	
PVC	0.	lbs	Amount of PVC: [PVC per well * number of wells + additional PVC pipe + PVC for manifold] * conversion factor. This value is calculated for Capital or both Capital and O&M projects.
Length of Steel Pipe per well	0.	ft/well	Length of steel pipe per well includes well screen.
Conversion factor	10.79	lbs/ft	Conversion factor for weight of steel pipe.
Other steel per well	0.	lbs	Other steel per well includes equipment such as pumps.
Other steel (system-wide, eg, treatment system)	0.	lbs	Other steel for system includes weight of air stripper or carbon tanks.
Steel	0.	lbs	Amount of steel: [Steel pipe per well * number of wells * conversion factor + Other steel per well * number of wells + other system components]. This value is calculated for Capital or both Capital and O&M projects.
Operating time	8,320.	hrs/yr	Amount of activated carbon, if required by treatment system, is based on average concentration in recovered groundwater (a function of pump rate, operating time and duration), and contaminant-specific parameters from Dobbs and Cohen, 1980. This value is calculated for O&M and both Capital and O&M projects.
Average concentration	0.0001	mg/L	
K parameter	28.		
1/n parameter	0.62		
Activated carbon	69.	lbs	
Power requirements	50.	kW per hr	Amount of electricity over project lifetime: Power requirements * Operating time in hours / year * Duration (input above). This value is calculated for O&M and both Capital and O&M projects.
Operating time	8,320.	hrs/yr	
Electricity	31,000,000.	kWh	

Linear feet for trenching	0.	ft
Trenching rate	300.	ft/hr
Trenching fuel consumption rate	0.	gal/hr
Fuel for trenching	0.	gal
Linear feet for drilling	0.	ft
Drilling rate	100.	ft/day
Drilling fuel consumption rate	0.	gal/day
Fuel for drilling	0.	gal
Total fuel (diesel; capital phase)	0.	gal
Vehicle mileage (transportation for activated carbon disposal)	5.	mpg
Miles traveled for activated carbon disposal (O&M)	0.	miles (project total)
Diesel (O&M phase)	0.	gal

Amount of diesel is based on the amount of fuel for trenching plus drilling. Diesel is calculated for Capital and both Capital and O&M projects.

Diesel for O&M is calculated based on transport for activated carbon.

Jet fuel use rate per passenger	0.0000097	gal/mi
Weight of passenger + luggage	200.	lbs
Total air miles (all passengers; input above)	0.	miles
Jet fuel (capital phase)	0.	gal
Jet fuel (O&M phase)	0.	gal
Vehicle mileage (travel)	15.	mpg
Miles traveled (capital)	0.	miles
Gasoline (capital)	0.	gal
Vehicle mileage (travel)	15.	mpg
Miles traveled (O&M)	500,000.	miles
Gasoline (O&M phase)	33,334.	gal
Total fuel (gasoline + jet fuel) - Capital phase	0.	gal
Total fuel (gasoline + jet fuel) - O&M phase	33,334.	gal

Total jet fuel: Jet fuel use rate * weight * air miles input above. The default calculation assumes 50% is used in capital, and 50% used in O&M phases.

Natural gas requirements for PT/Therm Ox

Operation Time	8,320.	hrs/yr
Natural gas flow rate	2.21	scfm
Natural gas for Therm Ox	0.	mcf

If treatment method is Air Stripper/Therm Ox, amount of natural gas: Natural gas flow rate * Duration (input above) * Operation time in hours per year * unit conversions.

Natural gas requirements for Activated Carbon regeneration

Conversion factor	0.	btu/lb activated carbon
Natural gas for activated carbon	0.	mcf
Natural gas used for metrics (Therm Ox or Activated Carbon)	0.	mcf

If treatment method is Activated Carbon, amount of natural gas: Amount of activated carbon (calculated above) * conversion factor.

Natural gas is used in metrics calculations for O&M and both Capital and O&M projects.

Metrics - Baseline Calculations

Technology Cost

Volume recovered	220,000.	1,000 gal/yr
Technology Cost (Capital)	4,100,000.	$
Technology Cost (O&M)	680,000.	$/year
Technology Cost (O&M)	51,000,000.	$ over project

Capital and O&M Costs are based on site data from USEPA 2001. Capital cost = [277189 * Volume ^ (-0.781)] * Volume. Annual O&M cost = [40500 * Volume ^ (-0.7706)] * Volume.

Energy Cost - Modify usage in Materials and Consumables (above). Update costs on Conversion tab

Safety/Accident Risk

Hours worked (Capital)	26,000.	hrs
Vehicle speed	40.	mph
Hours worked (O&M)	830,000.	hrs
Total hours worked	856,000.	hrs
Injuries per hour	2.74E-09	injuries/hr
Vehicle miles traveled (Capital)	0.	miles
Vehicle miles traveled (O&M)	500,000.	miles
Total vehicle miles traveled	500,000.	miles
Injuries per mile	9.10E-07	injuries/mi
Lost hours per injury	48.	hrs/injury
Safety/Accident Risk	22.	lost hours

Safety/Accident Risk: (Statistical number of injuries from time worked + injuries from miles traveled) * lost hours per injury.

SRT Input, Tailings Relocation by Excavation and Truck

EXCAVATION - TIER 2
Homestake Mining Superfund
Grants, NM
CAPITAL and O&M

Instructions:
[ ] = Enter your data here. Click button to the right of the cell for help.
[ ] = Use this default value or override with your own.
[ ] = Calculated value. You cannot change this.

Restore Defaults

Recommended flow:
Main → Input → Technology Design (You are here) → Results
- [x] Excavation
- [x] Soil Vapor Extraction
- [ ] Thermal Treatment

<< >>

Design for Managing Soil

Airline miles flown by project team (total miles for all travelers)		*miles over proj lifetime*
Average Distance Traveled by Site Workers per one-way trip	5	*miles one-way*
Trips by Site Workers during construction	20000	*# over project lifetime*
Trips by Site Workers after construction	0	*# over project lifetime*
Distance to Disposal (one-way)	20	*miles*
Type of Disposal	Hazardous	
Volume of affected soil	800,000,000.	*cu ft*
Volume of affected soil	29,629,630.	*cu yd*
Total hours to excavate	720,000.	*person-hours*
Number of loads for disposal	3,200,000.	*#*
Total miles driven for disposal	130,000,000.	*miles*
Total hours for fill dirt placement	88,000.	*hours*
Number of loads of fill dirt	990,000.	*#*
Total miles driven for fill	20,000,000.	*miles*

Tier 2: Change Calculated Values (dark gray cells)

Materials and Consumable Amounts used for Metrics

Diesel	21,000,000.	*gal*
Gasoline	13,000.	*gal*

Technology Cost

Capital	16,000,000,000.	$
O&M	n/a	$

Project-specific Metrics (Add & Subtract/Offsets)

Yes No

Additional Technology Cost		$
Total Energy Consumed		*Megajoules*
CO_2 Emissions to Atmosphere		*tons* CO_2
Safety / Accident Risk		*lost hours*

Design Calculations - Excavation

Area of Affected Soil	8,000,000.	*ft2*
Total Thickness of Affected Soil	100.	*ft*
Volume of affected soil	800,000,000.	*ft3*
Volume of affected soil	29,629,630.	*cu yd*
Soil density	95.	*lb/ft3*
Excavation rate	53.	*tons/hr*
Total hours to excavate	720,000.	*person-hours*

Volume of affected soil: Area * (Depth to Bottom - Depth to Top of Affected Soil).

Total hours to excavate: Volume of affected soil * soil density * (1 ton / 2000 lbs) * (1/rate of excavation in ton/hr).

Fluff factor (excavated soil)	1.3	
Dump truck volume for disposal	12.	*cu yd*
Number of loads for disposal	3,200,000.	*# loads*

Loads for disposal: Volume of affected soil * fluff factor * (1/dump truck volume) * (1 yd3 / 27 ft3 unit conversion).

Total miles driven for disposal	130,000,000.	*miles*

Total miles driven for disposal: Number of loads for disposal * 2 * Distance to disposal (input above).

Fluff factor (fill)	0.4	
Dump truck volume for moving fill	12.	*cu yd*
Number of loads of fill dirt	990,000.	*# loads*

Loads of fill dirt: Volume of affected soil (above) * fluff factor * (1/dump truck volume) * (1 yd3 / 27 ft3).

Fill spread rate	448.5	*cu yd/hr*
Water compaction rate	174.3	*cu yd/hr*
Spread/compaction rate	654.	*cu yd/hr*
Total hours for fill dirt placement	88,000.	*hrs*

Total hours for fill dirt placement, is the sum of: (1) Area (user input) * (1 yd2 / 9 ft2) / fill spread rate in yd3/hr. (2) Number of loads of fill dirt (calculated above) * dump truck volume (above) / rate of water compaction in yd3/hr. (3) Total volume of fill dirt / spread & compaction rate in yd3/hr.

Distance from site to fill source (one way)	10.	*miles*
Total miles driven for fill	20,000,000.	*miles*

Total miles driven for fill: Number of loads of fill dirt * 2 * Distance from site to fill source.

Materials and Consumable Calculations - Excavation

Excavator fuel consumption rate	3.	*gal/hr*
Dump truck fuel use rate	8.	*mpg*
Total fuel (diesel)	21,000,000.	*gals*

Total diesel: (Total hours to excavate & place fill * Excavator fuel consumption rate) + (Total miles driven for disposal * Dump truck fuel use rate)

Jet fuel use rate per passenger	0.0000097	*gal/mi*
Weight of passenger + luggage	200.	*lbs*
Total air miles (all passengers; input above)	0.	*miles*
Total jet fuel	0.	*gal*
Vehicle Mileage	15.	*mpg*
Total fuel (gasoline + jet fuel)	13,000.	*gal*

Total jet fuel: Jet fuel use rate* weight * air miles input above.

Total gasoline: (Construction + Postconstruction trips) * 2 * distance from office to site / vehicle mileage

Metrics - Baseline calculations (These calculations do not include Project-specific, direct additions / subtractions)

Technology Cost

Unit Cost (hazardous)	400.	*$/cu yd*
Volume	30,000,000.	*cu yd*
Fluff Factor (excavated soil)	1.3	
Technology Cost	16,000,000,000.	$

Technology cost is based on unit costs for disposal as hazardous waste (excavated volume * fluff * unit cost). For non-hazardous, costs are derived from RACER (Cost = (88.59 * excavated volume * fluff) + 4007). For excavation, all costs are assumed to be capital costs, expended within the first year.

Energy Cost - Energy usage can be modified in Materials and Consumables (above). Update costs on Conversion tab.

Safety/Accident Risk

Hours worked	840,000.	*hrs*
Vehicle Speed	40.	*mph*
Hours for travel (post-construction/site visit)	0.	*hrs*
Total hours worked	840,000.	*hrs*
Injuries per hour	2.74E-09	*injuries/hr*
Total vehicle miles traveled	150,200,000.	*miles*
Injuries per mile	9.10E-07	*injuries/mi*
Lost hours per injury	48.	*hrs/injury*
Safety/Accident Risk	6,600.	*lost hours*

Safety/Accident Risk: (Statistical number of injuries from time worked + injuries from miles traveled) * lost hours per injury.

SRT Output, Current Pump&Treat and Slurry Wall

GROUNDWATER OUTPUT

Instructions:
- (white box) = Enter your data here.
- (light grey box) = Use this default value or override with your own.
- (dark grey box) = Calculated value. You cannot change this.

Recommended flow:

Main → Input → Technology Design → Results (You are here*)

* Normalize metrics to see more, go back to Inputs to adjust and compare, go back to Main (for Tier 1/2 or Soil), or Exit.

Non-normalized

Calculations in natural units

	Carbon Dioxide Emissions to Atmosphere		NO_x*	SO_x	PM_{10}	Total Energy Consumed		Cost	NPV	Safety / Accident Risk		Change in Resource S
	tons CO_2	*lb CO_2 per lb dissolved mass*	*tons NO_x*	*tons SO_x*	*tons PM_{10}*	*Megajoules*	*kWh*	*dollars*	*dollars per lb dissolved mass*	*lost hours*	*injury risk*	*million gal*
Pump & Treat	81,000.	6,700.	480.	910.	170.	1,300,000,000.	360,000,000.	38,000,000.	1,600.	19.	4.0E-01	0.
Enhanced Bio.	-	-	-	-	-	-	-	-	-	-	-	-
ISCO	-	-	-	-	-	-	-	-	-	-	-	-
PRB	35,000.	2,900.	19.	0.018	0.89	30,000,000.	8,300,000.	79,000,000.	3,300.	790.	1.60E+01	400.
LTM / MNA	-	-	-	-	-	-	-	-	-	-	-	-

*: See SRT v.2 Known Issues

Normalize? Yes No

SRT Output, Reduced Pump&Treat and Slurry Wall

GROUNDWATER OUTPUT

Instructions:

= Enter your data here.

= Use this default value or override with your own.

= Calculated value. You cannot change this.

Recommended flow:

Main → Input → Technology Design → Results (You are here*)

* Normalize metrics to see more, go back to Inputs to adjust and compare, go back to Main (for Tier 1/2 or Soil), or Exit.

Non-normalized

Calculations in natural units

	Carbon Dioxide Emissions to Atmosphere		NO_x*	SO_x	PM_{10}	Total Energy Consumed		Cost	NPV	Safety / Accident Risk		Change in Resource S
	tons CO_2	*lb CO_2 per lb dissolved mass*	*tons NO_x*	*tons SO_x*	*tons PM_{10}*	*Megajoules*	*kWh*	*dollars*	*dollars per lb dissolved mass*	*lost hours*	*injury risk*	*million gal*
Pump & Treat	21,000.	1,700.	130.	240.	44.	350,000,000.	97,000,000.	55,000,000.	2,300.	22.	4.6E-01	0.
Enhanced Bio.	-	-	-	-	-	-	-	-	-	-	-	-
ISCO	-	-	-	-	-	-	-	-	-	-	-	-
PRB	35,000.	2,900.	19.	0.018	0.89	30,000,000.	8,300,000.	79,000,000.	3,300.	790.	1.60E+01	400.
LTM / MNA	-	-	-	-	-	-	-	-	-	-	-	-

*: See SRT v.2 Known Issues

Normalize? Yes No

SRT Output, Tailings Relocation by Excavation and Truck

SOIL/SOURCE RESULTS

Instructions:
- = Enter your data here.
- = Use this default value or override with your own.
- = Calculated value. You cannot change this.

Recommended flow:

Main → Input → Technology Design → Results

You are here*

* Normalize metrics to see more, go back to Inputs to adjust & compare, go back to Main (Tier 1/2 or GW), or Exit.

Non-normalized

Calculations in natural units

	Carbon Dioxide Emissions to Atmosphere		NO_x*	SO_x	PM_{10}	Total Energy Consumed		Technology Cost	
	tons CO_2	*lbs CO_2 per lb contam*	*tons NO_x*	*tons SOx*	*tons PM_{10}*	*Megajoules*	*kWh*	*dollars*	*dollars per lb contam*
Excavation	270,000.	360.	2,200.	2.1	100.	3,600,000,000.	1,000,000,000.	16,000,000,000.	11,000.
SVE	-	-	-	-	-	-	-	-	-
Thermal	-	-	-	-	-	-	-	-	-

*: See SRT v.2 Known Issues

Normalize? Yes No

APPENDIX D – EVAPORATION CALCULATIONS

Calculations of Evaporation Pond Capacities Necessary for Disposal of Treated and Collected Water Assuming Different Active Evaporation Spraying Scenarios

Conditions for the different active evaporation spraying scenarios were based on the volumes of water, both treated and untreated, calculated for the proposed pump and treat conditions assuming flushing of the Tailings Piles had ceased and the piles were being dewatered. Both the estimated volumes and concentrations were first checked against the current pump and treat system to ensure that the current treatment system could handle the proposed flows, contaminant concentrations, and water quality conditions. Table 1 indicates the current inlet flows, contaminant, and water quality conditions being observed at Homestake. Table 2 contains comparable information for the proposed pumping conditions. Table 3 compares the two sets of operating conditions. The inlet contaminant and water quality concentrations in the proposed pumping conditions are similar to those in the current treatment plant so it is expected that the current treatment system will be adequate in this regard. The proposed conditions involve a slightly higher flow rate of 450 gpm than the current pumping operations.. Homestake has indicated that the current treatment system can achieve at least a sustained flow rate of 540 gpm (Homestake, 2010), which indicates that the proposed flowrate is within the capacity of the current treatment system. It was concluded then that the current treatment system was adequate to handle both the proposed scenario and also for continued operation under the current conditions.

Table 1 Current Treatment Plant Operating Conditions (information supplied by Homestake from a pilot test using both RO treatment columns, Sept 2009)

Date	Total GW	Flow to Clarifier	Flow to RO	RO injection flow	Product out	Brine out	Ratio Brine/ Product	
		Gpm						
9/22/2009	404	418	405	272	308	98	0.24138	
9/28/2009	437	437	429	294	323	106	0.24709	
Average treatment feed values for current system (averaged over 2001-9, 2008 Homestake Annual Monitoring report and associated data from Homestake Access data base)								
	TDS clarifier	U clarifier	RO/ deep aquifer TDS	U RO +deep aquifer	Se clarifier	Se RO+ deep aquifer	Moly clarifier	Moly RO+deep aquifer
	5800 ppm	13.4 mg/L	260 ppm	0.031 mg/L	1.3 mg/L	0.014 mg/L	17.4 mg/L	0.08mg/L

Note: Deep aquifer water is added to the RO product water before reinjection

Table 2 Treatment Plant Operation Conditions for Proposed Pump and Treat Scenario (Note 1)

Source	Rate (gpm)	To	TDS (ppm)	TDS Avg	U(ppm)	UAvg	Se (pm)	Se Avg	Moly (ppm) Note 2	Moly Avg
Tailings	65	Ponds	> 5000		>10 ppm		0.3-0.6	0.45	50	50
SW line (LTP)	250	RO	2400-7000	4700	2-10	6.0	0.5-3	1.6	10	10
STP	150	RO	1100-4000	2550	2-16	10.0	1-4	2.5	1.5	1.5
L line	50	RO	700-1100	900	0.2-0.5	0.4	0.8	0.8	1	1
Total or avg in feed to RO	450			3561		6.7		1.8		6.2

Note 1: flows are intended to be conservative and may overestimate those necessary to contain plume

Table 3 Comparison of Average Flow Rates and Species Concentrations for Current and Proposed Treatment Systems Feed

	TDS (ppm)	U (mg/L)	Se (mg/L)	Moly (mg/L	Flow rate (gpm)	
Inlet Current	5800	13.4	1.3	17.4	415	(avg late Sept 2009, both RO columns operating)
Inlet Proposed	3600	6.7	1.8	6.2	450	

Disposal of the waste streams from the current and proposed pump and treat conditions were then used with different passive and active evaporation spraying scenarios to calculate the evaporation pond capacity necessary for each scenario.

The three scenarios for which calculations of evaporative pond capacities and corresponding pond surface areas were performed are the following:

1) Current active evaporative spray system with a) proposed and b) current systems
2) Active evaporation only on the proposed new pond under proposed conditions
3) Passive evaporation only on all ponds (existing and new proposed pond)

Calculations for the latter two scenarios were developed only for the proposed pumping conditions since that requires higher evaporative capacity; therefore, the pond areas calculated would also be sufficient for the current scenario. It is noted that a range of scenarios could be developed with different amounts of active evaporative spraying so these scenarios are only examples. Also, it was assumed in all the evaporation scenarios that the current treatment plant would not be augmented by additional treatment capacity, i.e. another high pressure RO unit or additional waste treatment through TDS reduction outside the current treatment plant. Additional treatment, which could lower the disposal demand on the ponds through lower waste generation, should be considered along with changes in active evaporation spraying and/or increases in the evaporation pond capacity. Overall optimization combinations are discussed more at the end of this section.

Table 4 shows the evaporative capacity needed for the current pumping. Table 5 shows the evaporative capacity needed for the proposed pumping conditions. The evaporative capacity of the existing ponds and the capacity of the existing ponds plus the proposed third pond (additional surface area of 30 acres) are both included in Table 6. The volumetric holding capacity of the ponds was not considered (i.e., the ponds' capacity to accept water only considered long-term evaporation, and not the volume to fill the ponds). Information provided verbally by Homestake indicates that the current ponds are near volumetric capacity.

Comparison of the current rate of waste discharge to the ponds and the current pond evaporation capacity indicates that under the current conditions, nearly all the evaporation capacity, both passive and active, of the existing evaporation pond system is being used. Comparison of the waste generation under the proposed pumping and treatment conditions indicates that discharge to the ponds would exceed the existing pond evaporative capacity for all the evaporative spraying scenarios (Table 7). For use of the current capacity of evaporative spraying at the existing ponds, approximately 11 acres of additional passive (non-spraying) evaporation pond surface area would need to be added for the proposed pumping conditions. If the same rate of evaporation spraying currently observed for the current ponds is used on an additional pond (but ceased on the existing ponds), an additional pond acreage of approximately 36 acres would be necessary. If no evaporation spraying was used on any of the ponds, a pond with approximately 52 acres of surface area would need to be added.

Table 4 Liquid to ponds, current pumping conditions		
Operating information from Sept 2009 pilot running both system operation, from Homestake 2008 Operating report		
Source	Feed Vol rate (gpm)	Vol rate (gpm)
Treatment Plant (assume 25% of feed)	240	60
Tailings Collection (direct to ponds)		50
Toe Drain Collection (direct to ponds)		11
Precipitation existing ponds (10 in/yr* 83ft/year*43 acres*43560sq ft/acre* 1 year/365 days*1 day/1440 min*7.48 =22 gpm)		22
Precipitation existing +30 acre new pond (10 in/yr* 83ft/year*73 acres*43560sq ft/acre* 1 year/365 days*1 day/1440 min*7.48 =37 gpm)		37
Total liquid to existing ponds, including precipitation		143
Total liquid to existing ponds and 30-acre additional pond, including precipitation		158

Table 5 Liquid to ponds, proposed pumping scenario

Assume 25% brine and blow-down -avg over treatment system operation, from Homestatke 2008 Operating report		
Source	Feed Vol rate (gpm)	Vol rate (assume 25% of feed) (gpm)
Treatment Plant	450	112.5
Tailings/Toe Collection (direct to ponds)		65
Precipitation existing ponds (10 in/yr* 83ft/year*43 acres*43560sq ft/acre* 1 year/365 days*1 day/1440 min*7.48 =22 gpm)		22
Precipitation (10 in/year) existing +30 acre new pond (10 in/yr* 83ft/year*43 acres*43560sq ft/acre* 1 year/365 days*1 day/1440 min*7.48 =37 gpm)		37
Total liquid to existing ponds, including precipitation		199.5
Total liquid to existing ponds and 30-acre additional pond, including precipitation		215

Table 6 Evaporative Capacity of Ponds	(gpm)
Present Pond evaporative capacity without evaporation sprayers (Homestake, 2010)	80
Present Pond evaporative capacity with evaporative sprayers (Homestake, 2010)	160
Proposed pond (30 acres) with only passive evaporative capacity	55.81
Proposed pond evaporative capacity with evaporative sprayers (30 acres)	111.63
Total evaporation, existing + proposed ponds, capacity w/o evaporative sprayers	135.81
Total evaporation capacity with evaporative sprayers only on proposed pond	191.63
Total evaporation, existing ponds with evaporative sprayers, passive evaporation only on proposed 30-acrea pond	215.81
Total evaporation, existing + proposed ponds, capacity with evaporative sprayers	271.63

Table 7 Shortfalls in Evaporative Pond Capacity and Pond Additional Areas Needed	
Liquid capacity shortfall existing ponds, current pond/evaporation, proposed conditions	40 gpm
Liquid capacity shortfall, existing ponds, active evaporation only 3rd pond, 30 acres surface area assumed, proposed conditions	23 gpm
Liquid capacity shortfall existing ponds, no active evaporation, proposed conditions	97 gpm
Pond area necessary (with current active spraying) to augment current ponds	11 acres
Area of proposed pond if evaporative spraying used only on 3rd pond	36 acres
Area of proposed pond, no evaporative spraying any ponds	52 acres

Combination of Evaporative Capacity with other Waste Minimization Optimizations

The shortfall of evaporative capacity and volume of liquid to the evaporation ponds under the proposed pumping conditions, assuming continuation of the existing evaporative spraying system, is approximately 40gpm. This shortfall could be reduced by additional pond capacity or by reduction of liquid load. The latter could be achieved by the following:

1. Treatment of the majority of the toe and tailings water. Currently, Homestake is collecting ~61 gpm of toe/tailings water. Under the proposed pumping conditions 65 gpm would be collected. Assuming the current treatment efficiency (75% product, 25% brine/blowdown), the loading to the ponds could be reduced by nearly the capacity shortfall if the toe/tailings water under the current and proposed conditions was treated. The sustainable treatment flow rate is at least 540 gpm (Homestake 2010), with the increased feed flow rate (480 – 500 gpm) d still achieveable within the current treatment system. However, as both the contaminant concentrations and the salt concentrations in the feed would be higher than those currently being treated, pilots for additional toe/tailings treatment would need to be performed to determine if the contaminants are treated to acceptable levels and the pretreatment adequate for system operation.
2. Addition of a second high pressure RO unit to the current RO system. The current high pressure RO unit extracts approximately 40 gpm of product following extraction by one of the low pressure RO units. Assuming that addition of a second high pressure RO column would have similar extraction efficiency, a second high pressure RO unit would also potentially address nearly all of the capacity shortfall.

APPENDIX E – EVAPORATIVE SPRAYING EQUIPMENT INFORMATION

TO: Dave Becker, RSE Team

FROM: Paul Robinson

DATE: March 18, 2010

SUBJECT: Evaporation Rate Materials

TURBOMISTER – a supplier of spray evaporation equipment used at Evaporation Pond 1 at the HMC site has a wide range of material on the theory and practice of spray evaporation.

An overview of spray evaporation rate considerations, including droplet size, evaporator through put and other factors is at:
http://www.turbomister.com/turbomist-evap-rates.php

An evaporation efficiency conversion chart relating pan evaporation achieved in inches per month to volume of pond circulated through the evaporators is at:
http://www.turbomister.com/PDFs/Efficiency%20conversion%20Table%20Turbomist.pdf - copy attached

A technical paper addressing evaporation theory and practice including consideration of spray fallback factor in spray evaporation rate evaluation is at:
http://www3.interscience.wiley.com/journal/112475413/abstract?CRETRY=1&SRETRY=0 - copy attached

Gregory P. Flach, Frank C. Sappington, and Kenneth L. Dixon, "Field Performance of a Fan-Driven Spray Evaporator", REMEDIATION, Spring 2006

ABSTRACT
"An emerging evaporation technology uses a powerful axial fan and high-pressure spray nozzles to propel a fine mist into the atmosphere at high air and water flow rates. Commercial units have been deployed at several locations in North America and worldwide since the mid-1990s, typically in arid or semiarid climates. A commercial spray evaporator was field tested at the U.S. Department of Energy's Savannah River Site in South Carolina to develop quantitative performance data under relatively humid conditions. A semi-empirical correlation was developed from eight tests from March through August 2003. For a spray rate of 250 L/min (66 gpm) and continuous year-round operation at the Savannah River Site, the predicted average evaporation rate is 48 L/min (13 gpm)." © 2006 Washington Savannah River Company*

CONVERSION TABLE FROM NET PAN EVAPORATION TO TURBOMIST EFFICIENCY ESTIMATES FOR THE TURBOMIST S30P EVAPORATOR

This chart is indicated in inches per month. If you have annual pan evaporation in feet, convert to inches
And divide the total by 12 months to determine the average pan evaporation rate to use below.

Net Pan evaporation (Inches / month) Inches	Percentage of Volume Pumped aloft	Net Pan evaporation (Inches / month) Inches	Percentage of volume Pumped aloft
1.5	20%	9.5	45%
1.75	24%	10	46%
2	27%	10.5	47%
2.25	28%	11	48%
2.5	29%	11.5	49%
3	30%	12	50%
3.25	31%	12.5	51%
3.5	32%	13	52%
3.75	33%	13.5	53%
4	34%	14	54%
4.5	35%	14.5	55%
5	36%	15	56%
5.5	37%	15.5	57%
6	38%	16	58%
6.5	39%	16.5	59%
7	40%	17	60%
7.5	41%	17.5	61%
8	42%	18	62%
8.5	43%	18.5	63%
9	44%	19	64%

This conversion chart is the property of Slimline Manufacturing Ltd an is intended to give our evaporator custom base a conservative estimate of what our S30P evaporator models will do at their site, based upon the net pan evaporation provided.

Field Performance of a Fan-Driven Spray Evaporator

Gregory P. Flach

Frank C. Sappington

Kenneth L. Dixon

*An emerging evaporation technology uses a powerful axial fan and high-pressure spray nozzles to propel a fine mist into the atmosphere at high air and water flow rates. Commercial units have been deployed at several locations in North America and worldwide since the mid-1990s, typically in arid or semiarid climates. A commercial spray evaporator was field tested at the U.S. Department of Energy's Savannah River Site in South Carolina to develop quantitative performance data under relatively humid conditions. A semiempirical correlation was developed from eight tests from March through August 2003. For a spray rate of 250 L/min (66 gpm) and continuous year-round operation at the Savannah River Site, the predicted average evaporation rate is 48 L/min (13 gpm). © 2006 Washington Savannah River Company**

INTRODUCTION

Evaporation provides one mechanism for reducing the volume of wastewater, a common component of an overall wastewater management strategy. Example applications include mining, distillation and textile plants, animal waste disposal, phosphate fertilizer production, and landfill management. Evaporation also has application to groundwater remediation. For example, the Savannah River Site (SRS) is using phytoremediation to reduce the discharge of tritiated groundwater to a stream (Blount et al., 2002). The remediation project involves capturing a tritium (H-3) plume in a man-made pond located at the seepline, and spray-irrigating the collected water over an upgradient mixed pine and deciduous forest. Enhanced evapotranspiration can significantly reduce the net flux of tritium discharging to surface water (Blount et al., 2002). However, evapotranspiration demand is minimal during winter months, and heavy precipitation in any season significantly increases influx to the collection pond due to surface runoff. Under these circumstances, the net influx can exceed the holding capacity of the pond, causing overflow. Thus, a supplemental technology, such as spray evaporation, was desired to remove excess water from the collection pond during winter and wet periods.

An emerging evaporation technology uses a powerful axial fan and high-pressure spray nozzles to propel a fine mist into the atmosphere at high air and water flow rates. Commercial examples include the Slimline Manufacturing Ltd. Turbo-mist (http://www.turbomist.com/) and SMI® Super Polecat evaporators (http://www.evapor.com/). Such evaporators rely on the sensible heat that can be extracted from unsaturated (< 100 percent humidity) air to drive evaporation. Incoming "dry" air is brought into contact with the spray field through a combination of the mechanical fan and natural wind, and simulta-

Published online in Wiley Interscience (www.interscience.wiley.com). DOI: 10.1002/rem.20083

neously cooled and humidified through evaporation. Because the energy for evaporation comes from a natural source, the overall cost is relatively low.

Field performance of these evaporators is affected by a number of factors, including the flow rate, temperature, and humidity of the air contacting the spray field, and the spatial distribution, suspension time, and size of spray droplets. Hot, dry, and windy conditions are most favorable to spray evaporation, and units have been commercially deployed at several locations in North America and worldwide since the mid-1990s, typically in arid or semiarid climates. Although anecdotal information and limited field measurements (Ferguson, 1999) suggest the technology is effective, at least in arid climates, quantitative performance data under more humid conditions are not available. Such data were needed to evaluate the technology for application at the SRS tritium phytoremediation site.

When unsaturated air is brought into contact with liquid water, with no heat transfer to or from the overall system, liquid evaporates and air is cooled until thermodynamic equilibrium is reached.

The purpose of this technical note is to provide evaporator performance data for Southeast U.S. climate conditions, and to present a semiempirical correlation for predicting evaporation near the range of conditions tested. The field data were acquired at the U.S. Department of Energy's Savannah River Site near Aiken, South Carolina, from late March through mid-August 2003. The specific system tested is the Slimline Turbomist evaporator.

EVAPORATION PRINCIPLES

When unsaturated air is brought into contact with liquid water, with no heat transfer to or from the overall system, liquid evaporates and air is cooled until thermodynamic equilibrium is reached (100 percent humidity). Such a process is termed adiabatic saturation and is the principle behind swamp coolers used for residential cooling in the Southwest United States and agricultural cooling (e.g., poultry houses). The energy required to vaporize liquid water (latent heat of vaporization) is extracted from unsaturated air through cooling (sensible heat). The amount of cooling as a function of the temperature and relative humidity of the incoming air stream can be determined through application of the first law of thermodynamics, which states that enthalpy is conserved in a open system. With minor approximation, the adiabatic saturation process can be described by:

$$h^*_{in} = (h_a + \gamma h_m)_{in} + (h_a + \gamma h_w)_{out} + h^*_{out} \quad (1)$$

where h^* = enthalpy of moist air per unit mass of dry air, h_a = enthalpy of dry air, γ = specific humidity or humidity ratio, and h_w = enthalpy of water vapor (Reynolds and Perkins, 1977). The thermodynamic properties of moist air can be readily computed from an American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) handbook (e.g., ASHRAE, 1985) or equivalent source.

As an example calculation, the annual average temperature and relative humidity at the Savannah River Site are 18°C (65°F) and 68 percent, respectively (Hunter & Tatum, 1997). For these conditions, the evaporative cooling achieved when the incoming air stream is saturated is 3.7°C (6.6°F). Exhibit 1 shows contours of constant evaporative cooling degrees resulting from various combinations of temperature and relative humidity. The dashed box defines an approximate envelope of likely weather conditions at the Savannah River Site.

 Remediation DOI: 10.1002.rem

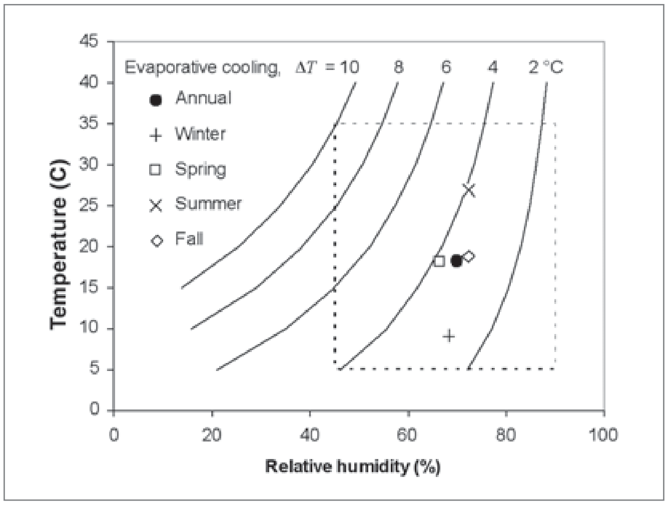


Exhibit 1. Evaporative cooling potential as a function of temperature and relative humidity

Spray evaporation under atmospheric conditions is expected to be proportional to the cooling and evaporation amounts computed under adiabatic saturation conditions. For evaporation to be sustained, air (and water) must be continuously supplied to replenish the system. An energy balance expanding on Eq. (1) indicates that evaporation of liquid water into unsaturated air is proportional to the mass flow rate of air delivered to the system. For atmospheric spray evaporation, fresh air is delivered to the spray field through natural winds. Thus, the spray evaporation rate is also expected to be proportional to local wind speed. The overall dimensions of the spray field, and the distribution, suspension time, and size of spray droplets within, are also expected to affect the evaporation rate.

EXPERIMENT DESIGN AND SETUP

In many evaporator applications, water is drawn from a holding pond (e.g., mine tailings) and sprayed into the air. Droplets not evaporated fall back into the pond. At the Savannah River Site, deployment over dry land was under consideration, leading into field testing. For this situation, high evaporation with little or no fallback was considered to be optimal. Therefore, field testing focused on reduced spray rates (20 to 150 L/min) and smaller droplet sizes compared to that produced by the vendor's default spray nozzle configuration (~250 L/min). Ultimately, the evaporator was deployed at the phytoremediation collection pond, for which fallback was not a concern.

To measure evaporator performance for a particular nozzle configuration and weather condition, specialized collection devices were deployed on a grid to measure spray fallback. The evaporation rate was then computed as the spray rate minus the fallback rate. The surveyed grid system is depicted in Exhibit 2, along with an example fallback pattern. A 6.1-m (20-ft) square spacing was chosen near the origin of the grid where the spray evaporator was located. Collection devices were deployed at a variety of grid locations to handle particular weather conditions—primarily, wind speed and direction. To handle a wide range of potential fallback amounts over the duration of a field

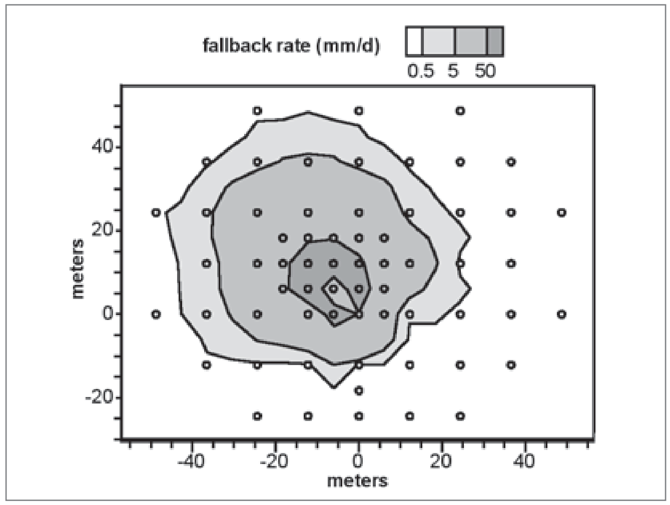


Exhibit 2. Grid system defining placement of spray fallback collection devices, and an example fallback pattern

test, both rain gauges and absorbent pads were used. For each absorbent pad, fallback was determined from the area, and dry (pre-test) and wet (post-test) weights of the pad.

FIELD TESTING AND DATA

Eight field tests were conducted between March and August 2003 (Flach et al., 2003). Comparison of the fallback measurements from the absorbent pads and rain gauges from all tests indicated that the pads are capable of reliably retaining fallback amounts up to approximately 5 mm (0.2 in) of water, while at least 5 mm (0.2 in) is needed with a rain gauge to avoid readings that are biased low. Thus, if a rain gauge reading exceeded 5 mm at an individual grid location, that value was adopted as the fallback amount. Otherwise, the absorbent pad measurement was selected. For each test, a map of spray fallback was created by interpolating the point data from the preferred collection device at each grid location onto a regular 6.1 m (20 ft) $\times$ 6.1 m (20 ft) grid using a kriging interpolation algorithm (Isaaks & Srivastava, 1989). Numerical integration of the kriged surface produced the total amount of spray fallback for a given test.

Exhibit 3 summarizes the evaporator configuration, average weather conditions, and spray fallback for each field test. Because testing was conducted from March through August, periods of rainfall were avoided, and daytime testing was preferred for logistical reasons, most tests were conducted at relatively warm temperatures and moderate humidity. An exception was the 16-hour overnight test beginning at 4:21 P.M. on March 31 and ending at 8:58 A.M. on April 1, for which the average conditions were 3.5°C (38.3°F), 72% relative humidity, and 0.85 m/s (1.9 mph) wind speed. These conditions were unfavorable for evaporation, and the evaporation rate was low.

DATA CORRELATION

Because the collection of test data summarized in Exhibit 3 only defines evaporator performance under certain specific conditions, a model capable of predicting evapora-

  Remediation DOI: 10.1002.rem

	Nozzle configuration					Weather conditions		
Test date	No.	Cores	Orifices	Spray rate (L/min)	Evap. rate (L/min)	Temp. (°C)	Rel. hum. (%)	Wind speed (m/s)
03/31/03	30	25	D2	23	6.9	4	69	1.3
04/29/03	30	25	D2	23	20	25	52	2.1
05/01/03	30	25	D5	59	25	26	56	3.1
05/14/03	30	25	D5	63	22	22	46	0.9
06/25/03	30	25	D5	61	31	31	41	1.6
06/26/03	27	45	D6	96	50	31	46	2.2
07/24/03	27	45	D6	99	43	29	56	2.0
08/11/03	30	45	D8	148	53	29	64	2.9

Exhibit 3. Summary of evaporator field testing results

tion rates under more arbitrary conditions is desirable. Following the previously stated expectation that the evaporation rate is largely proportional to the evaporative cooling potential based on adiabatic saturation and wind speed, the dimensional evaporation data are first normalized as

$$E' = \frac{E}{a \cdot \Delta T \cdot V} \tag{2}$$

where E' = normalized evaporation rate, E = evaporation rate, a = empirical constant, ΔT = evaporative cooling, and V = wind speed.

Similarly, the spray rate is normalized as

$$Q' = \frac{Q}{a \cdot \Delta T \cdot V} \tag{3}$$

where Q' = normalized spray rate, Q = spray rate, a = empirical constant, ΔT = evaporative cooling, and V = wind speed.

The evaporation rate is zero when the spray rate is zero. The field data suggest the evaporation rate increases in proportion to spray rate initially but levels off at higher spray rates. A nondimensional empirical function capturing this qualitative behavior is

$$E' = \frac{1}{1 + \frac{b}{Q'}} \tag{4}$$

where E' = normalized evaporation rate, b = empirical constant, and Q' = normalized spray rate. The limiting behavior of Eq. (4) is $E' \rightarrow 0$ as $Q' \rightarrow 0$, and $E' \rightarrow 1$ as $Q' \rightarrow \infty$. In terms of dimensional parameters, Eq. (4) is equivalent to the semiempirical model:

 Remediation DOI: 10.1002.rem

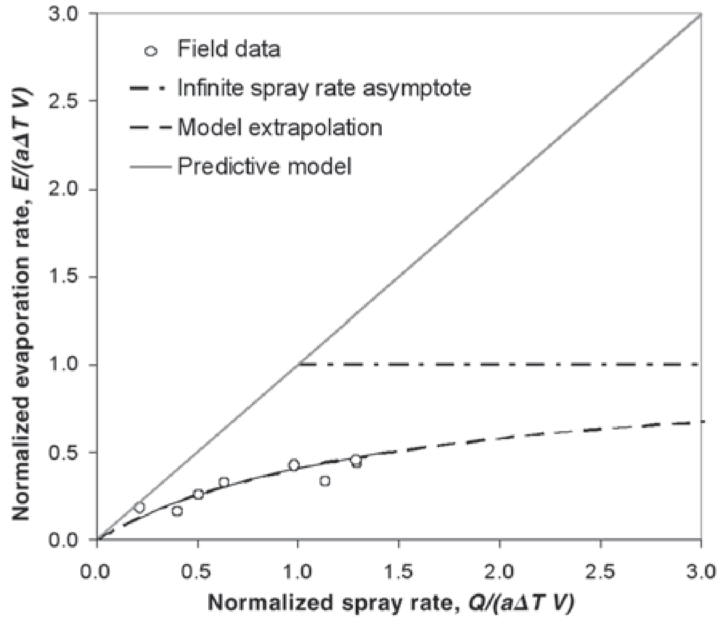


Exhibit 4. Normalized evaporation and spray rates

$$E = \frac{1}{\frac{1}{a \cdot \Delta T \cdot V} + \frac{b}{Q}} \quad (5)$$

with limits of $E \rightarrow 0$ as $Q \rightarrow 0$, and $E \rightarrow a \cdot \Delta T \cdot V$ as $Q \rightarrow \infty$. Optimal values for the empirical constants a and b were determined using least-squares parameter fitting, with the result of $a = 1.24 \times 10^{-4} m^2/°C$ (0.49 gpm/°F – mph) and $b = 1.45$(unitless). Normalized evaporation rate is plotted against normalized spray rate in Exhibit 4. The model is observed to fit the field data reasonably well.

While the functional form given by Eq. (5) incorporates two factors influencing evaporation, other important parameters (droplet size, residence time, etc.) are not explicitly considered. The latter influences are implicitly embedded in the empirical constants a and b. Furthermore, limited field data were available to define optimal values and test the robustness of the selected correlation. Thus, the predictive model is applicable to the particular commercial system and environmental conditions tested. Extrapolation to other evaporator models and weather conditions should be done with caution.

The nondimensional predictive model defined by Eq. (4) can be translated into the equivalent dimensional form given by Eq. (5) for specific weather conditions (i.e., values of ΔT and V). For the default spray rate of 250 L/min (66 gpm) and continuous year-round operation at the Savannah River Site ($\Delta T = 3.7°C$, $V = 2.4$ m/s,), the predicted average evaporation rate is 48 L/min (13 gpm).

 Remediation DOI: 10.1002.rem

COST ANALYSIS

During field experimentation at the Savannah River Site, all power required to operate the evaporator (axial fan and water pump) was supplied through a single portable diesel generator. Power usage varied little during and between tests, and averaged 30 kW. Electricity costs commercial users in the Southeast United States approximately $0.09 per kW-hr. For the projected annual average evaporation rate of 13 gpm, the projected treatment cost is $3.50 per 1,000 gallons of water evaporated.

ACKNOWLEDGMENTS

The work described in this technical note was performed at the Savannah River National Laboratory by Westinghouse Savannah River Company LLC for the U.S. Department of Energy under Contract No. DE-AC09-96SR18500. The authors are grateful to these institutions for permission to publish their findings and for the support of Phil Prater, DOE Project Team Lead. We also thank colleagues Susan Bell, John Bennett, Gerald Blount, and Mo Kasraii for critical program support and technical assistance.

NOMENCLATURE

a, b = empirical constants
h^* = enthalpy of moist air per unit mass of dry air
h_a = enthalpy of dry air
h_w = enthalpy of water vapor
E = evaporation rate
E' = normalized evaporation rate
Q = spray rate
Q' = normalized spray rate
V = wind speed
ΔT = evaporative cooling potential based on temperature and relative humidity
γ = specific humidity or humidity ratio

REFERENCES

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). (1985). ASHRAE handbook: 1985 fundamentals. Atlanta, GA: Author.

Blount, G. C., Caldwell, C. C., Cardoso-Neto, J. E., Conner, K. R., Jannik, G. T., Murphy Jr., C. E., et al. (2002). The use of natural systems to remediate groundwater: Department of Energy experience at the Savannah River Site. Remediation, 12(3), 43–61.

Ferguson, R. B. (1999). Management of tailings pond water at the Kettle River Operation. CIM Bulletin, 92(1029), 67–69.

Flach, G. P., Sappington, F. G., & Dixon, K. L. (2003). Field performance of a Slimline Turbomist evaporator under Southeastern U. S. climate conditions (U). WSRC-RP-2003-00429. Aiken, SC: Westinghouse Savannah River Company. Retrieved October 7, 2005, from http://sti.srs.gov/fulltext/rp2003429/rp2003429.pdf

Hunter, C. H., & Tatum, C. P., (1997). Meteorological annual report for 1996 (U). WSRC-TR-97-0214. Aiken, SC: Westinghouse Savannah River Company. Retrieved October 7, 2005, from http://www.osti.gov/dublincore/ecd/servlets/purl/574238-oiySQz/webviewable/574238.pdf

Isaaks, E. H., & Srivastava, R. M. (1989). An introduction to applied geostatistics. Oxford, UK: Oxford University Press.

Reynolds, W. C., & Perkins, H. C. (1977). Engineering thermodynamics. New York: McGraw-Hill.

Gregory P. Flach, PhD, P.E., is a fellow engineer at the Savannah River National Laboratory (SRNL), where he has worked the past 17 years on a variety of environmental and nuclear engineering topics. He currently specializes in mathematical analysis and numerical simulation of porous media transport.

Frank C. Sappington, retired principal engineer at the Savannah River National Laboratory, has 22 years of civil engineering experience. At SRNL, he developed, deployed, and tested new groundwater remediation technologies, horizontal and vertical barrier systems, and groundwater extraction systems. His BS degree in civil engineering is from the Southern Polytechnic State University.

Kenneth L. Dixon, P.E., is a principal engineer at the Savannah River National Laboratory, where he has worked the past 14 years on a variety of environmental engineering projects. He specializes in pilot-scale testing of innovative remedial technologies and numerical simulation of contaminant transport in the vadose zone.

 Remediation DOI: 10.1002.rem

APPENDIX F – RESRAD SUMMARY REPORT

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	Ac-227 (Source: FGR 12)	4.951E-04	4.951E-04	DCF1(1)
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(2)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(3)
A-1	Bi-211 (Source: FGR 12)	2.559E-01	2.559E-01	DCF1(4)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(5)
A-1	Fr-223 (Source: FGR 12)	1.980E-01	1.980E-01	DCF1(6)
A-1	Pa-231 (Source: FGR 12)	1.906E-01	1.906E-01	DCF1(7)
A-1	Pa-234 (Source: FGR 12)	1.155E+01	1.155E+01	DCF1(8)
A-1	Pa-234m (Source: FGR 12)	8.967E-02	8.967E-02	DCF1(9)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(10)
A-1	Pb-211 (Source: FGR 12)	3.064E-01	3.064E-01	DCF1(11)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(12)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(13)
A-1	Po-211 (Source: FGR 12)	4.764E-02	4.764E-02	DCF1(14)
A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(15)
A-1	Po-215 (Source: FGR 12)	1.016E-03	1.016E-03	DCF1(16)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(17)
A-1	Ra-223 (Source: FGR 12)	6.034E-01	6.034E-01	DCF1(18)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(19)
A-1	Rn-219 (Source: FGR 12)	3.083E-01	3.083E-01	DCF1(20)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(21)
A-1	Th-227 (Source: FGR 12)	5.212E-01	5.212E-01	DCF1(22)
A-1	Th-230 (Source: FGR 12)	1.209E-03	1.209E-03	DCF1(23)
A-1	Th-231 (Source: FGR 12)	3.643E-02	3.643E-02	DCF1(24)
A-1	Th-234 (Source: FGR 12)	2.410E-02	2.410E-02	DCF1(25)
A-1	Tl-207 (Source: FGR 12)	1.980E-02	1.980E-02	DCF1(26)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(27)
A-1	U-234 (Source: FGR 12)	4.017E-04	4.017E-04	DCF1(28)
A-1	U-235 (Source: FGR 12)	7.211E-01	7.211E-01	DCF1(29)
A-1	U-238 (Source: FGR 12)	1.031E-04	1.031E-04	DCF1(30)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.724E+00	6.700E+00	DCF2(1)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(2)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(3)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(4)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(5)
B-1	U-234	1.320E-01	1.320E-01	DCF2(6)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(7)
B-1	U-238	1.180E-01	1.180E-01	DCF2(8)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(9)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.410E-02	DCF3(1)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(2)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(3)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(4)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(5)
D-1	U-234	2.830E-04	2.830E-04	DCF3(6)

Dose Conversion Factor (and Related) Parameter Summary (continued)

Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-1	U-235+D	2.673E-04	2.660E-04	DCF3(7)
D-1	U-238	2.550E-04	2.550E-04	DCF3(8)
D-1	U-238+D	2.687E-04	2.550E-04	DCF3(9)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(2,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(3,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(3,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(3,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(4,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,3)
D-34				
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(5,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(5,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(5,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(6,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(6,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(6,3)
D-34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(7,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(7,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(7,3)
D-34				
D-34	U-238 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(8,1)
D-34	U-238 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(8,2)
D-34	U-238 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(8,3)
D-34				
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(9,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(9,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(9,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(2,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(2,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(3,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(3,2)

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: FGR 12 & FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(4,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(4,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(5,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(5,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(6,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(6,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC(7,1)
D-5	U-235+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(7,2)
D-5				
D-5	U-238 , fish	1.000E+01	1.000E+01	BIOFAC(8,1)
D-5	U-238 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(8,2)
D-5				
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC(9,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(9,2)

#For DCF1(xxx) only, factors are for infinite depth & area. See ETFG table in Ground Pathway of Detailed Report.
*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.000E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.000E+00	2.000E+00	---	THICK0
R011	Fraction of contamination that is submerged	0.000E+00	0.000E+00	---	SUBMFRACT
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): U-234	1.000E+01	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): U-235	5.000E-01	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g): U-238	1.000E+01	0.000E+00	---	S1(8)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(8)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	3.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+00	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	2.540E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	6.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	3.300E+03	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	4.200E-03	2.000E-02	---	HGWT
R014	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	1.400E+01	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	3.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+00	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.667E-03	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(7,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.667E-03	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(8,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.667E-03	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R016	Distribution coefficients for daughter Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.631E-03	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.667E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.336E-03	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for daughter Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.907E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for daughter Th-230				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.231E-06	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	5.000E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	9.200E+01	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.300E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	5.400E+00	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	1.000E+00	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	5.000E-01	5.000E-01	---	FR9
R018	Contamination fraction of plant food	-1	-1	0.500E+00	FPLANT
R018	Contamination fraction of meat	-1	-1	0.500E+00	FMEAT
R018	Contamination fraction of milk	-1	-1	0.500E+00	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	1.000E+00	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	1.500E-01	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	2.400E+00	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	1.000E-01	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	3.000E-02	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	3.000E-07	3.000E-07	---	DIFFL
R021	in contaminated zone soil	2.000E-06	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	2.000E+00	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	5.000E-01	5.000E-01	---	REXG
R021	Height of the building (room) (m)	2.500E+00	2.500E+00	---	HRM
R021	Building interior area factor	0.000E+00	0.000E+00	code computed (time dependent)	FAI
R021	Building depth below ground surface (m)	-1.000E+00	-1.000E+00	code computed (time dependent)	DMFL
R021	Emanating power of Rn-222 gas	2.500E-01	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	active
Find peak pathway doses	suppressed

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	10000.00 square meters	U-234	1.000E+01
Thickness:	2.00 meters	U-235	5.000E-01
Cover Depth:	0.00 meters	U-238	1.000E+01

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	3.353E+00	3.344E+00	3.327E+00	3.266E+00	3.101E+00	2.596E+00	1.627E+00	6.247E-01
M(t):	1.341E-01	1.338E-01	1.331E-01	1.307E-01	1.240E-01	1.038E-01	6.510E-02	2.499E-02

Maximum TDOSE(t): 3.353E+00 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	3.288E-03	0.0010	1.312E-01	0.0391	4.490E-07	0.0000	6.151E-01	0.1834	2.029E-02	0.0061	4.975E-02	0.0148	1.032E-01	0.0308
U-235	3.062E-01	0.0913	6.115E-03	0.0018	0.000E+00	0.0000	2.910E-02	0.0087	9.671E-04	0.0003	2.350E-03	0.0007	4.875E-03	0.0015
U-238	1.215E+00	0.3623	1.173E-01	0.0350	3.181E-13	0.0000	5.840E-01	0.1742	1.927E-02	0.0057	4.724E-02	0.0141	9.795E-02	0.0292
=======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======
Total	1.524E+00	0.4546	2.547E-01	0.0760	4.490E-07	0.0000	1.228E+00	0.3663	4.053E-02	0.0121	9.934E-02	0.0296	2.060E-01	0.0614

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.228E-01	0.2752
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.496E-01	0.1043
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.081E+00	0.6205
=======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.353E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	3.280E-03	0.0010	1.309E-01	0.0391	3.139E-06	0.0000	6.134E-01	0.1834	2.024E-02	0.0061	4.962E-02	0.0148	1.029E-01	0.0308
U-235	3.054E-01	0.0913	6.100E-03	0.0018	0.000E+00	0.0000	2.912E-02	0.0087	9.851E-04	0.0003	2.344E-03	0.0007	4.866E-03	0.0015
U-238	1.212E+00	0.3623	1.170E-01	0.0350	4.764E-12	0.0000	5.824E-01	0.1742	1.922E-02	0.0057	4.711E-02	0.0141	9.769E-02	0.0292
=======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======
Total	1.520E+00	0.4546	2.540E-01	0.0760	3.139E-06	0.0000	1.225E+00	0.3663	4.044E-02	0.0121	9.908E-02	0.0296	2.054E-01	0.0614

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.203E-01	0.2752
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.488E-01	0.1043
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.075E+00	0.6205
=======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.344E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
U-234	3.264E-03	0.0010	1.302E-01	0.0391	1.654E-05	0.0000	6.102E-01	0.1834	2.013E-02	0.0061	4.936E-02	0.0148	1.023E-01	0.0308
U-235	3.038E-01	0.0913	6.071E-03	0.0018	0.000E+00	0.0000	2.916E-02	0.0088	1.021E-03	0.0003	2.331E-03	0.0007	4.849E-03	0.0015
U-238	1.205E+00	0.3623	1.164E-01	0.0350	5.538E-11	0.0000	5.793E-01	0.1741	1.912E-02	0.0057	4.686E-02	0.0141	9.717E-02	0.0292
Total	1.512E+00	0.4546	2.527E-01	0.0760	1.654E-05	0.0000	1.219E+00	0.3663	4.027E-02	0.0121	9.855E-02	0.0296	2.044E-01	0.0614

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.155E-01	0.2752
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.472E-01	0.1044
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.064E+00	0.6204
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.327E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	3.221E-03	0.0010	1.278E-01	0.0391	1.462E-04	0.0000	5.989E-01	0.1834	1.976E-02	0.0060	4.844E-02	0.0148	1.005E-01	0.0308
U-235	2.982E-01	0.0913	5.978E-03	0.0018	0.000E+00	0.0000	2.933E-02	0.0090	1.145E-03	0.0004	2.289E-03	0.0007	4.795E-03	0.0015
U-238	1.183E+00	0.3621	1.143E-01	0.0350	1.449E-09	0.0000	5.686E-01	0.1741	1.876E-02	0.0057	4.600E-02	0.0141	9.537E-02	0.0292
Total	1.484E+00	0.4544	2.480E-01	0.0759	1.462E-04	0.0000	1.197E+00	0.3664	3.967E-02	0.0121	9.673E-02	0.0296	2.006E-01	0.0614

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.987E-01	0.2752
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.417E-01	0.1046
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.026E+00	0.6202
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.266E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	3.192E-03	0.0010	1.212E-01	0.0391	1.192E-03	0.0004	5.679E-01	0.1831	1.874E-02	0.0060	4.593E-02	0.0148	9.527E-02	0.0307
U-235	2.829E-01	0.0912	5.751E-03	0.0019	0.000E+00	0.0000	2.990E-02	0.0096	1.471E-03	0.0005	2.171E-03	0.0007	4.669E-03	0.0015
U-238	1.121E+00	0.3616	1.083E-01	0.0349	3.410E-08	0.0000	5.391E-01	0.1739	1.779E-02	0.0057	4.361E-02	0.0141	9.042E-02	0.0292
Total	1.407E+00	0.4539	2.353E-01	0.0759	1.192E-03	0.0004	1.137E+00	0.3666	3.800E-02	0.0123	9.171E-02	0.0296	1.904E-01	0.0614

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.535E-01	0.2752
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.268E-01	0.1054
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.921E+00	0.6194
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.101E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	4.017E-03	0.0015	1.007E-01	0.0388	1.150E-02	0.0044	4.727E-01	0.1821	1.559E-02	0.0060	3.813E-02	0.0147	7.917E-02	0.0305
U-235	2.355E-01	0.0907	5.139E-03	0.0020	0.000E+00	0.0000	3.145E-02	0.0121	2.341E-03	0.0009	1.807E-03	0.0007	4.331E-03	0.0017
U-238	9.304E-01	0.3584	8.990E-02	0.0346	1.065E-06	0.0000	4.474E-01	0.1723	1.476E-02	0.0057	3.619E-02	0.0139	7.504E-02	0.0289
=======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======
Total	1.170E+00	0.4506	1.958E-01	0.0754	1.150E-02	0.0044	9.515E-01	0.3665	3.269E-02	0.0126	7.613E-02	0.0293	1.585E-01	0.0611

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.218E-01	0.2780
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.806E-01	0.1081
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.594E+00	0.6139
=======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.596E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	1.118E-02	0.0069	5.951E-02	0.0366	7.422E-02	0.0456	2.875E-01	0.1767	9.466E-03	0.0058	2.260E-02	0.0139	4.696E-02	0.0289
U-235	1.396E-01	0.0858	3.696E-03	0.0023	0.000E+00	0.0000	2.987E-02	0.0184	3.246E-03	0.0020	1.069E-03	0.0007	3.359E-03	0.0021
U-238	5.457E-01	0.3353	5.277E-02	0.0324	1.947E-05	0.0000	2.626E-01	0.1614	8.665E-03	0.0053	2.124E-02	0.0131	4.404E-02	0.0271
Total	6.966E-01	0.4280	1.160E-01	0.0713	7.424E-02	0.0456	5.800E-01	0.3564	2.138E-02	0.0131	4.491E-02	0.0276	9.436E-02	0.0580

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.115E-01	0.3143
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.809E-01	0.1111
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.351E-01	0.5746
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.627E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	3.979E-02	0.0637	1.011E-02	0.0162	2.859E-01	0.4576	9.068E-02	0.1452	2.934E-03	0.0047	4.612E-03	0.0074	9.078E-03	0.0145
U-235	2.239E-02	0.0358	9.374E-04	0.0015	0.000E+00	0.0000	1.075E-02	0.0172	1.505E-03	0.0024	1.705E-04	0.0003	9.585E-04	0.0015
U-238	8.438E-02	0.1351	8.175E-03	0.0131	2.007E-04	0.0003	4.070E-02	0.0652	1.343E-03	0.0021	3.291E-03	0.0053	6.823E-03	0.0109
=======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======
Total	1.466E-01	0.2346	1.922E-02	0.0308	2.861E-01	0.4579	1.421E-01	0.2275	5.782E-03	0.0093	8.073E-03	0.0129	1.686E-02	0.0270

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.431E-01	0.7093
U-235	9.244E-10	0.0000	3.066E-11	0.0000	0.000E+00	0.0000	2.130E-10	0.0000	4.752E-13	0.0000	7.623E-13	0.0000	3.671E-02	0.0588
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.449E-01	0.2320
=======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======
Total	9.244E-10	0.0000	3.066E-11	0.0000	0.000E+00	0.0000	2.130E-10	0.0000	4.752E-13	0.0000	7.623E-13	0.0000	6.247E-01	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	9.228E-02	9.203E-02	9.154E-02	8.985E-02	8.517E-02	7.065E-02	4.142E-02	6.389E-03
U-234	Th-230	1.000E+00	4.808E-07	1.402E-06	3.230E-06	9.551E-06	2.697E-05	8.108E-05	1.898E-04	3.183E-04
U-234	Ra-226+D	1.000E+00	5.357E-08	3.758E-07	1.983E-06	1.755E-05	1.431E-04	1.381E-03	8.925E-03	3.472E-02
U-234	Pb-210+D	1.000E+00	4.767E-11	6.171E-10	6.475E-09	1.524E-07	3.073E-06	6.490E-05	6.125E-04	2.877E-03
U-234	§DSR(j)		9.228E-02	9.203E-02	9.155E-02	8.987E-02	8.535E-02	7.218E-02	5.115E-02	4.431E-02
U-235+D	U-235+D	1.000E+00	6.991E-01	6.972E-01	6.935E-01	6.807E-01	6.453E-01	5.354E-01	3.141E-01	4.854E-02
U-235+D	Pa-231	1.000E+00	1.171E-04	3.654E-04	8.609E-04	2.554E-03	7.048E-03	1.927E-02	3.373E-02	1.723E-02
U-235+D	Ac-227+D	1.000E+00	8.194E-07	5.134E-06	2.507E-05	1.974E-04	1.265E-03	6.421E-03	1.396E-02	7.640E-03
U-235+D	§DSR(j)		6.992E-01	6.976E-01	6.944E-01	6.834E-01	6.536E-01	5.611E-01	3.618E-01	7.342E-02
U-238	U-238	5.400E-05	4.474E-06	4.462E-06	4.438E-06	4.356E-06	4.130E-06	3.426E-06	2.010E-06	3.106E-07
U-238+D	U-238+D	9.999E-01	2.081E-01	2.075E-01	2.064E-01	2.026E-01	1.921E-01	1.593E-01	9.347E-02	1.445E-02
U-238+D	U-234	9.999E-01	1.307E-07	3.913E-07	9.082E-07	2.674E-06	7.365E-06	2.013E-05	3.530E-05	1.815E-05
U-238+D	Th-230	9.999E-01	4.674E-13	3.138E-12	1.623E-11	1.420E-10	1.151E-09	1.104E-08	7.021E-08	2.717E-07
U-238+D	Ra-226+D	9.999E-01	3.787E-14	5.696E-13	6.636E-12	1.739E-10	4.093E-09	1.279E-07	2.341E-06	2.437E-05
U-238+D	Pb-210+D	9.999E-01	2.839E-17	7.539E-16	1.687E-14	1.164E-12	6.914E-11	5.062E-09	1.480E-07	1.979E-06
U-238+D	§DSR(j)		2.081E-01	2.075E-01	2.064E-01	2.026E-01	1.921E-01	1.594E-01	9.350E-02	1.449E-02

§ is used to indicate summation; the Greek sigma is not included in this font.
The DSR includes contributions from associated (half-life <= 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	2.709E+02	2.716E+02	2.731E+02	2.782E+02	2.929E+02	3.464E+02	4.888E+02	5.643E+02
U-235	3.575E+01	3.584E+01	3.600E+01	3.658E+01	3.825E+01	4.455E+01	6.911E+01	3.405E+02
U-238	1.202E+02	1.205E+02	1.211E+02	1.234E+02	1.302E+02	1.569E+02	2.674E+02	1.725E+03

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
U-234	1.000E+01	0.000E+00	9.228E-02	2.709E+02	9.228E-02	2.709E+02
U-235	5.000E-01	0.000E+00	6.992E-01	3.575E+01	6.992E-01	3.575E+01
U-238	1.000E+01	0.000E+00	2.081E-01	1.202E+02	2.081E-01	1.202E+02

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	9.228E-01	9.203E-01	9.154E-01	8.985E-01	8.517E-01	7.065E-01	4.142E-01	6.389E-02
U-234	U-238	9.999E-01	1.307E-06	3.913E-06	9.082E-06	2.674E-05	7.365E-05	2.013E-04	3.530E-04	1.815E-04
U-234	§DOSE(j)		9.228E-01	9.203E-01	9.154E-01	8.985E-01	8.518E-01	7.067E-01	4.145E-01	6.407E-02
Th-230	U-234	1.000E+00	4.808E-06	1.402E-05	3.230E-05	9.551E-05	2.697E-04	8.108E-04	1.898E-03	3.183E-03
Th-230	U-238	9.999E-01	4.674E-12	3.138E-11	1.623E-10	1.420E-09	1.151E-08	1.104E-07	7.021E-07	2.717E-06
Th-230	§DOSE(j)		4.808E-06	1.402E-05	3.230E-05	9.552E-05	2.697E-04	8.109E-04	1.899E-03	3.186E-03
Ra-226	U-234	1.000E+00	5.357E-07	3.758E-06	1.983E-05	1.755E-04	1.431E-03	1.381E-02	8.925E-02	3.472E-01
Ra-226	U-238	9.999E-01	3.787E-13	5.696E-12	6.636E-11	1.739E-09	4.093E-08	1.279E-06	2.341E-05	2.437E-04
Ra-226	§DOSE(j)		5.357E-07	3.758E-06	1.983E-05	1.755E-04	1.431E-03	1.382E-02	8.927E-02	3.475E-01
Pb-210	U-234	1.000E+00	4.767E-10	6.171E-09	6.475E-08	1.524E-06	3.073E-05	6.490E-04	6.125E-03	2.877E-02
Pb-210	U-238	9.999E-01	2.839E-16	7.539E-15	1.687E-13	1.164E-11	6.914E-10	5.062E-08	1.480E-06	1.979E-05
Pb-210	§DOSE(j)		4.767E-10	6.171E-09	6.475E-08	1.524E-06	3.073E-05	6.490E-04	6.127E-03	2.879E-02
U-235	U-235	1.000E+00	3.495E-01	3.486E-01	3.468E-01	3.403E-01	3.227E-01	2.677E-01	1.570E-01	2.427E-02
Pa-231	U-235	1.000E+00	5.856E-05	1.827E-04	4.305E-04	1.277E-03	3.524E-03	9.635E-03	1.687E-02	8.617E-03
Ac-227	U-235	1.000E+00	4.097E-07	2.567E-06	1.253E-05	9.871E-05	6.326E-04	3.210E-03	6.980E-03	3.820E-03
U-238	U-238	5.400E-05	4.474E-05	4.462E-05	4.438E-05	4.356E-05	4.130E-05	3.426E-05	2.010E-05	3.106E-06
U-238	U-238	9.999E-01	2.081E+00	2.075E+00	2.064E+00	2.026E+00	1.921E+00	1.593E+00	9.347E-01	1.445E-01
U-238	§DOSE(j)		2.081E+00	2.075E+00	2.064E+00	2.026E+00	1.921E+00	1.593E+00	9.347E-01	1.445E-01

THF(i) is the thread fraction of the parent nuclide.
§ is used to indicate summation; the Greek sigma is not included in this font.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	1.000E+01	9.973E+00	9.920E+00	9.737E+00	9.230E+00	7.657E+00	4.489E+00	6.924E-01
U-234	U-238	9.999E-01	0.000E+00	2.827E-05	8.437E-05	2.760E-04	7.850E-04	2.171E-03	3.819E-03	1.966E-03
U-234	§S(j):		1.000E+01	9.973E+00	9.920E+00	9.737E+00	9.231E+00	7.659E+00	4.492E+00	6.944E-01
Th-230	U-234	1.000E+00	0.000E+00	8.990E-05	2.690E-04	8.882E-04	2.595E-03	7.896E-03	1.855E-02	3.113E-02
Th-230	U-238	9.999E-01	0.000E+00	1.274E-10	1.142E-09	1.253E-08	1.089E-07	1.070E-06	6.850E-06	2.657E-05
Th-230	§S(j):		0.000E+00	8.990E-05	2.690E-04	8.882E-04	2.595E-03	7.897E-03	1.855E-02	3.116E-02
Ra-226	U-234	1.000E+00	0.000E+00	1.947E-08	1.746E-07	1.918E-06	1.669E-05	1.652E-04	1.079E-03	4.417E-03
Ra-226	U-238	9.999E-01	0.000E+00	1.839E-14	4.946E-13	1.807E-11	4.697E-10	1.522E-08	2.827E-07	3.100E-06
Ra-226	§S(j):		0.000E+00	1.947E-08	1.746E-07	1.918E-06	1.669E-05	1.652E-04	1.080E-03	4.420E-03
Pb-210	U-234	1.000E+00	0.000E+00	2.001E-10	5.305E-09	1.843E-07	4.183E-06	9.204E-05	8.781E-04	4.137E-03
Pb-210	U-238	9.999E-01	0.000E+00	1.420E-16	1.132E-14	1.323E-12	9.215E-11	7.133E-09	2.117E-07	2.844E-06
Pb-210	§S(j):		0.000E+00	2.001E-10	5.305E-09	1.843E-07	4.183E-06	9.205E-05	8.783E-04	4.140E-03
U-235	U-235	1.000E+00	5.000E-01	4.987E-01	4.960E-01	4.868E-01	4.615E-01	3.829E-01	2.246E-01	3.472E-02
Pa-231	U-235	1.000E+00	0.000E+00	1.055E-05	3.148E-05	1.030E-04	2.929E-04	8.094E-04	1.421E-03	7.269E-04
Ac-227	U-235	1.000E+00	0.000E+00	1.660E-07	1.451E-06	1.460E-05	1.008E-04	5.244E-04	1.146E-03	6.285E-04
U-238	U-238	5.400E-05	5.400E-04	5.386E-04	5.357E-04	5.258E-04	4.985E-04	4.136E-04	2.426E-04	3.750E-05
U-238	U-238	9.999E-01	9.999E+00	9.973E+00	9.920E+00	9.736E+00	9.230E+00	7.658E+00	4.492E+00	6.943E-01
U-238	§S(j):		1.000E+01	9.973E+00	9.920E+00	9.737E+00	9.231E+00	7.659E+00	4.492E+00	6.944E-01

THF(i) is the thread fraction of the parent nuclide.
§ is used to indicate summation; the Greek sigma is not included in this font.

RESCALC.EXE execution time =   11.83 seconds

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.529E-09	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.650E-09	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.103E-10	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.472E-09	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.505E-10	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.537E-06	0.1644
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.759E-06	0.1302
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.662E-05	0.7053
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.193E-05	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 0.000E+00 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	6.752E-10	1.317E-09	1.668E-09	3.262E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	6.752E-10	1.317E-09	1.668E-09	3.262E-09	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	6.072E-08	0.0012	7.980E-07	0.0154	6.922E-09	0.0001	5.993E-06	0.1154	1.977E-07	0.0038	4.847E-07	0.0093	1.005E-06	0.0194
U-235	6.332E-06	0.1219	3.594E-08	0.0007	0.000E+00	0.0000	3.074E-07	0.0059	1.030E-08	0.0002	2.478E-08	0.0005	5.144E-08	0.0010
U-238	2.625E-05	0.5054	6.783E-07	0.0131	1.459E-13	0.0000	7.568E-06	0.1457	2.497E-07	0.0048	6.122E-07	0.0118	1.269E-06	0.0244
Total	3.264E-05	0.6285	1.512E-06	0.0291	6.922E-09	0.0001	1.387E-05	0.2670	4.577E-07	0.0088	1.122E-06	0.0216	2.326E-06	0.0448

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	1.308E-15	0.0000	5.827E-17	0.0000	4.048E-16	0.0000	9.032E-19	0.0000	1.449E-18	0.0000	2.520E-08	0.0048
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.788E-09	0.0015
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.136E-07	0.0790
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.168E-06	0.2230
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.780E-08	0.0034
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.928E-07	0.1132
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.693E-07	0.0896
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.543E-06	0.4856
=======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======
Total	1.308E-15	0.0000	5.827E-17	0.0000	4.048E-16	0.0000	9.032E-19	0.0000	1.449E-18	0.0000	5.237E-06	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+03 years

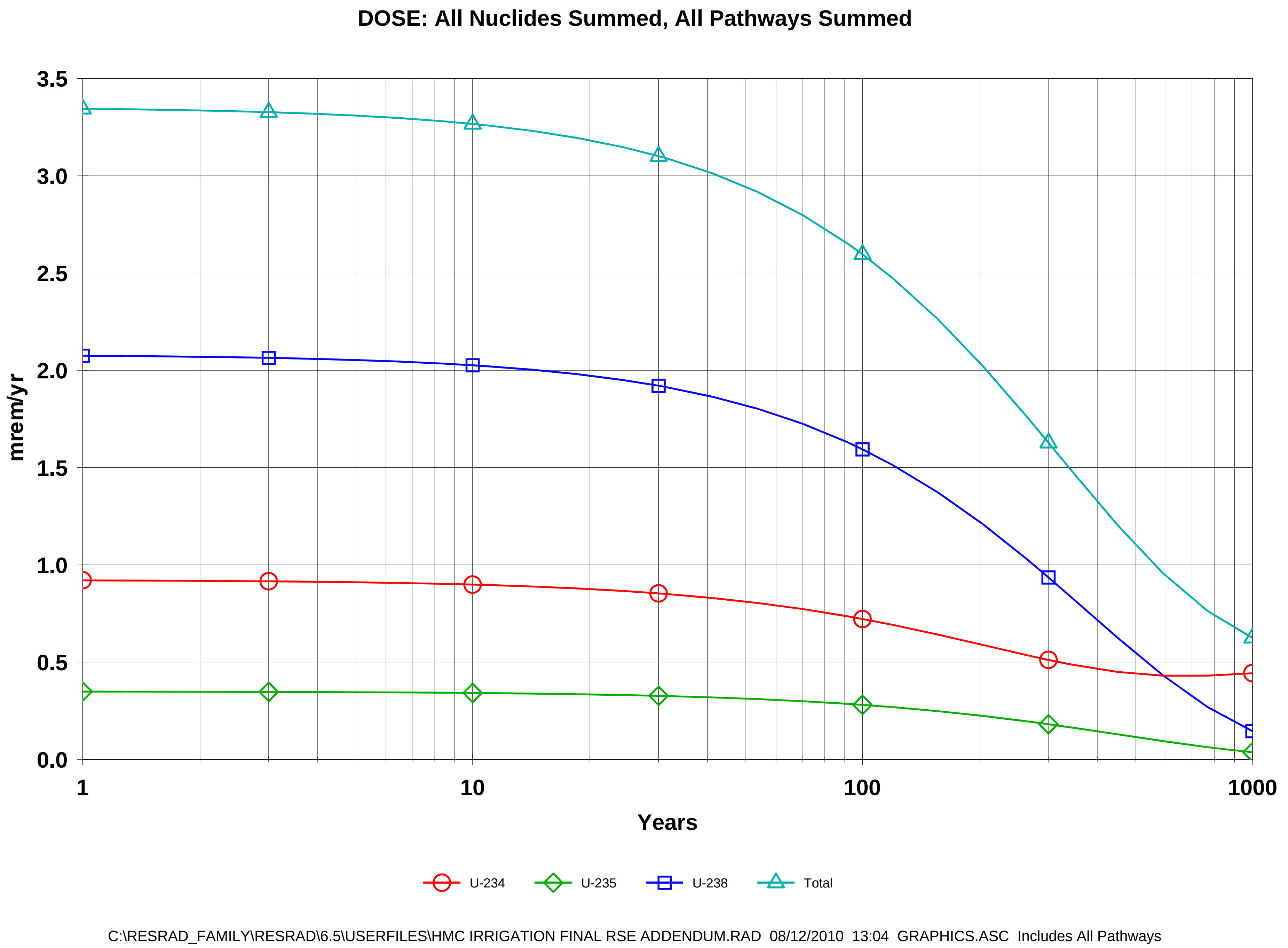
Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	4.983E-07	9.740E-07	1.234E-06	2.414E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
===========	==========	==========	==========	==========	==========	==========	==========	==========
Total	4.983E-07	9.740E-07	1.234E-06	2.414E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent   Water-dep. == Water-dependent

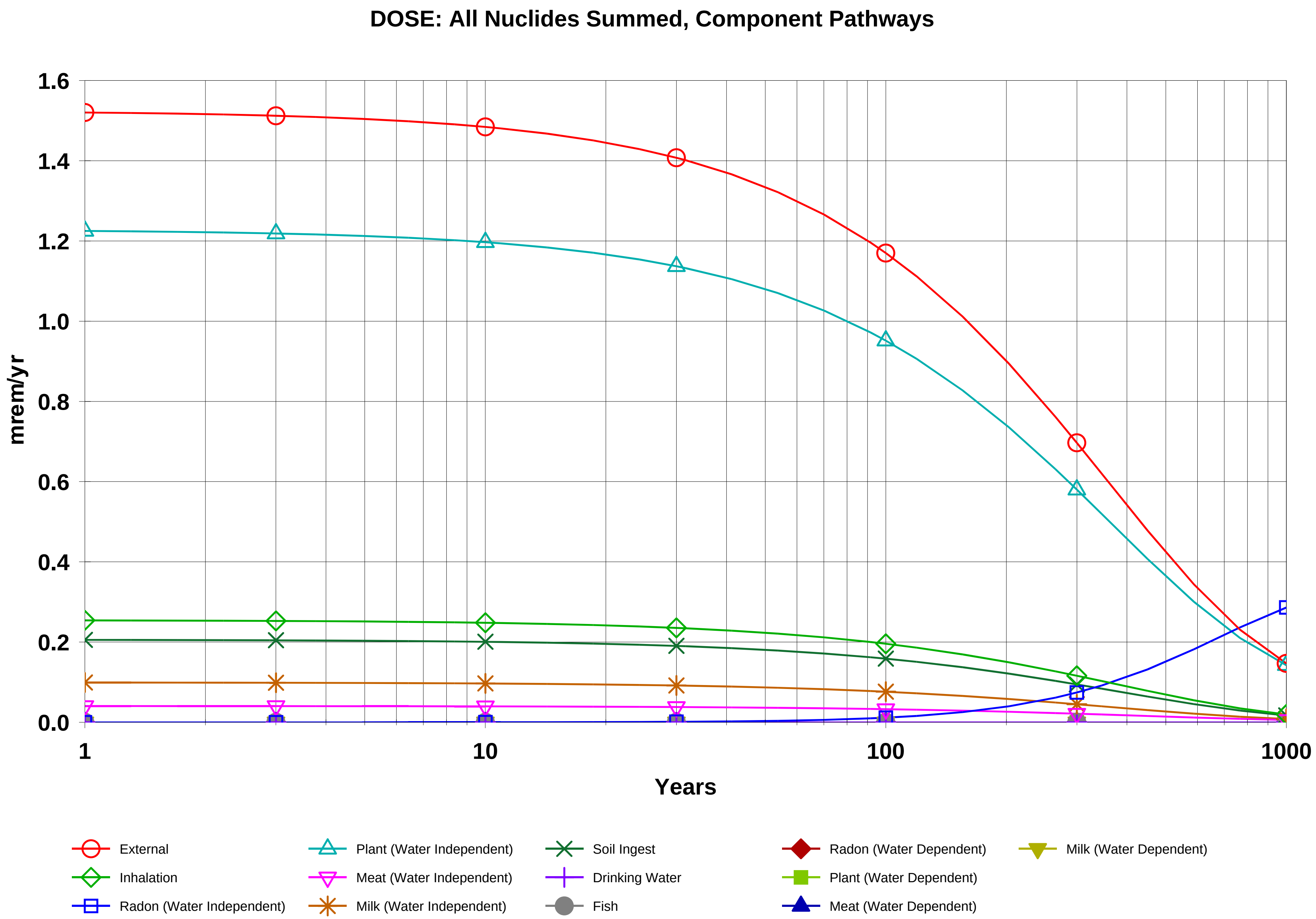
Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	9.139E-07	0.0882	5.917E-08	0.0057	5.116E-06	0.4940	1.042E-06	0.1006	3.388E-08	0.0033	4.844E-08	0.0047	9.194E-08	0.0089
U-235	4.637E-07	0.0448	3.042E-09	0.0003	0.000E+00	0.0000	2.807E-08	0.0027	1.605E-09	0.0002	1.729E-09	0.0002	4.181E-09	0.0004
U-238	1.823E-06	0.1760	4.725E-08	0.0046	3.626E-09	0.0004	5.271E-07	0.0509	1.739E-08	0.0017	4.261E-08	0.0041	8.835E-08	0.0085
=======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======
Total	3.201E-06	0.3090	1.095E-07	0.0106	5.120E-06	0.4943	1.597E-06	0.1542	5.288E-08	0.0051	9.278E-08	0.0090	1.845E-07	0.0178

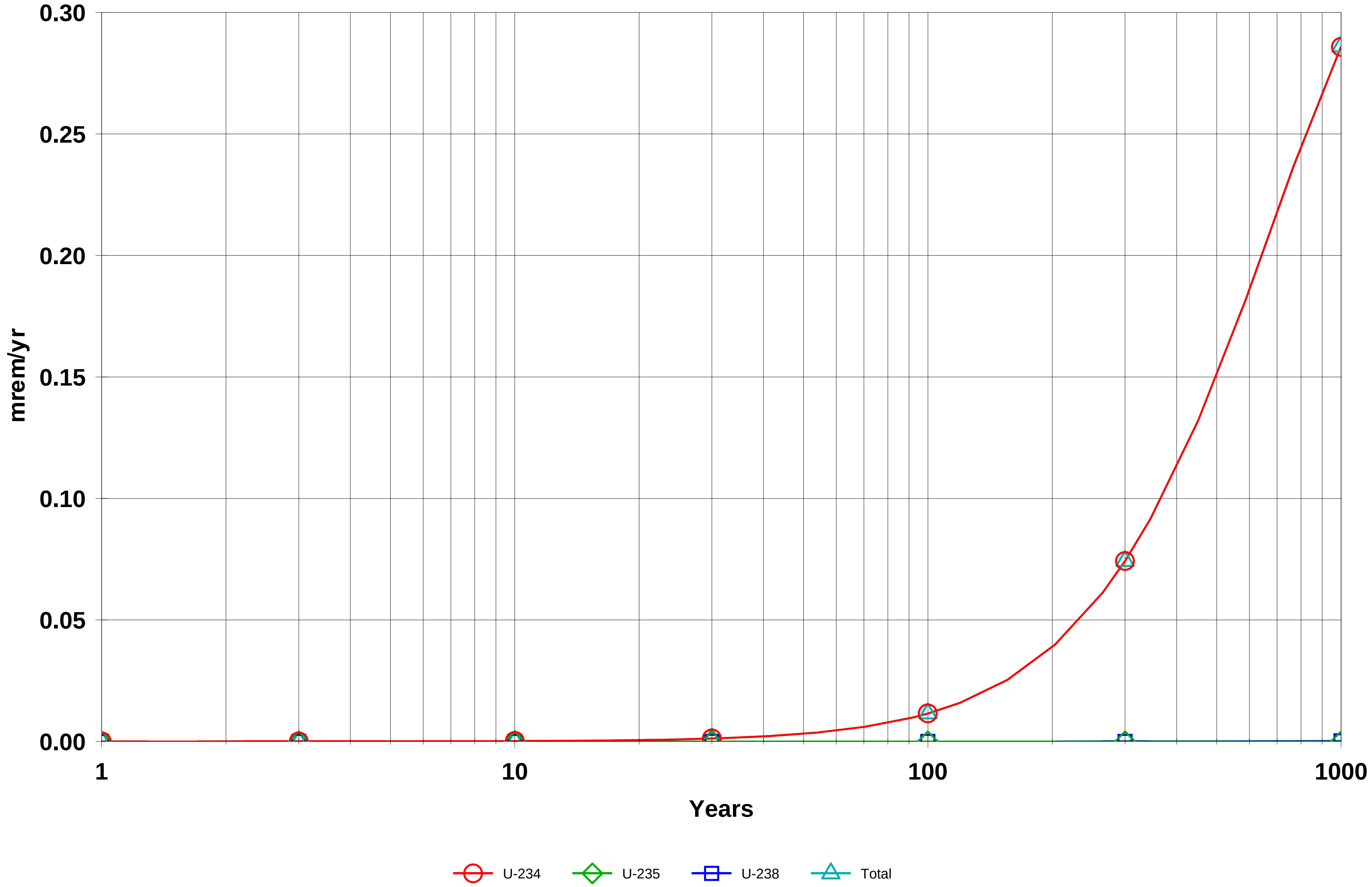


DOSE: All Nuclides Summed, All Pathways Summed
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
mrem/yr
1
10
100
1000
Years
U-234
U-235
U-238
Total
C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\HMC IRRIGATION FINAL RSE ADDENDUM.RAD 08/12/2010 13:04 GRAPHICS.ASC Includes All Pathways

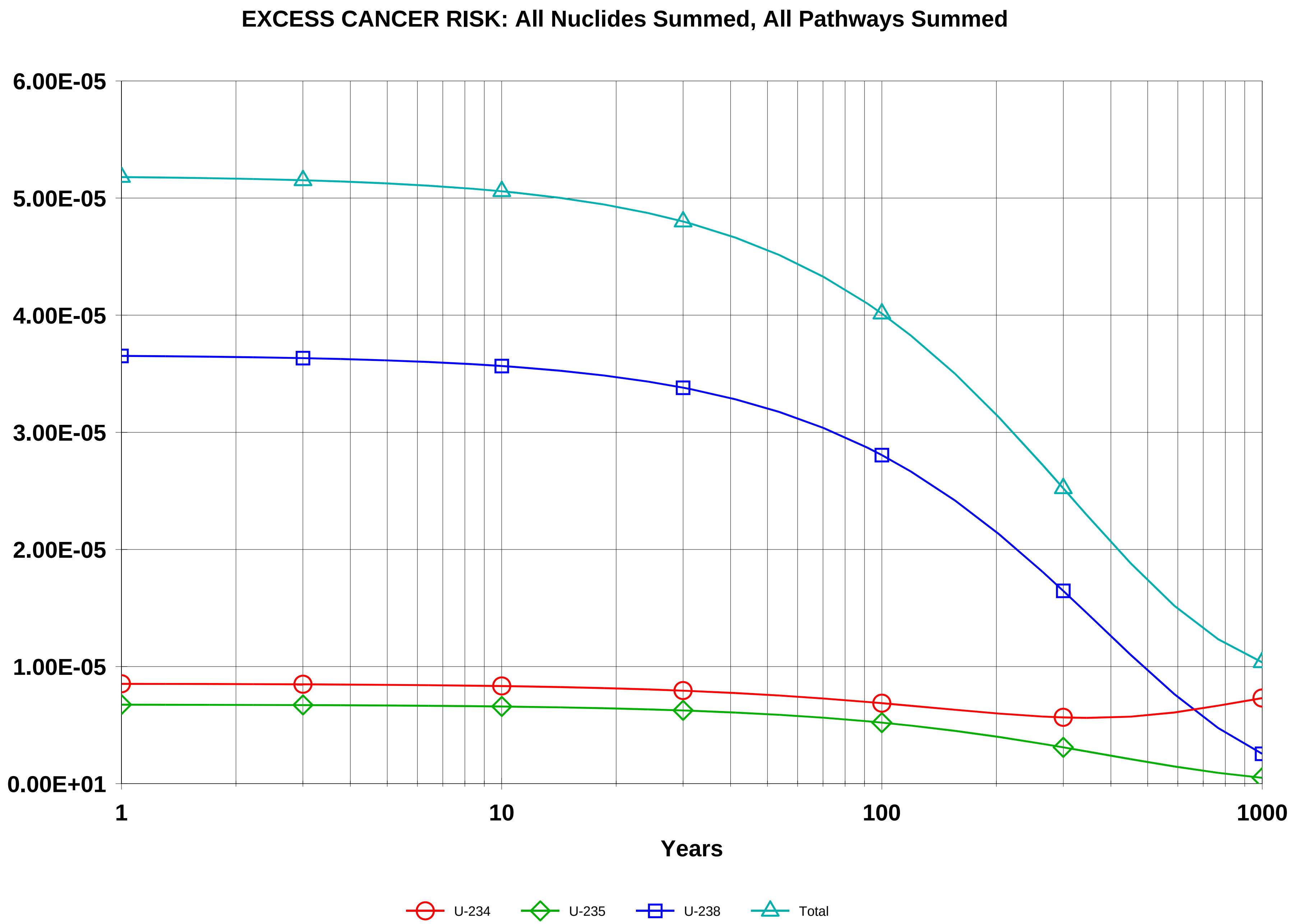


C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\HMC IRRIGATION FINAL RSE ADDENDUM.RAD 08/12/2010 13:04 GRAPHICS.ASC

DOSE: All Nuclides Summed, Radon (Water Independent)

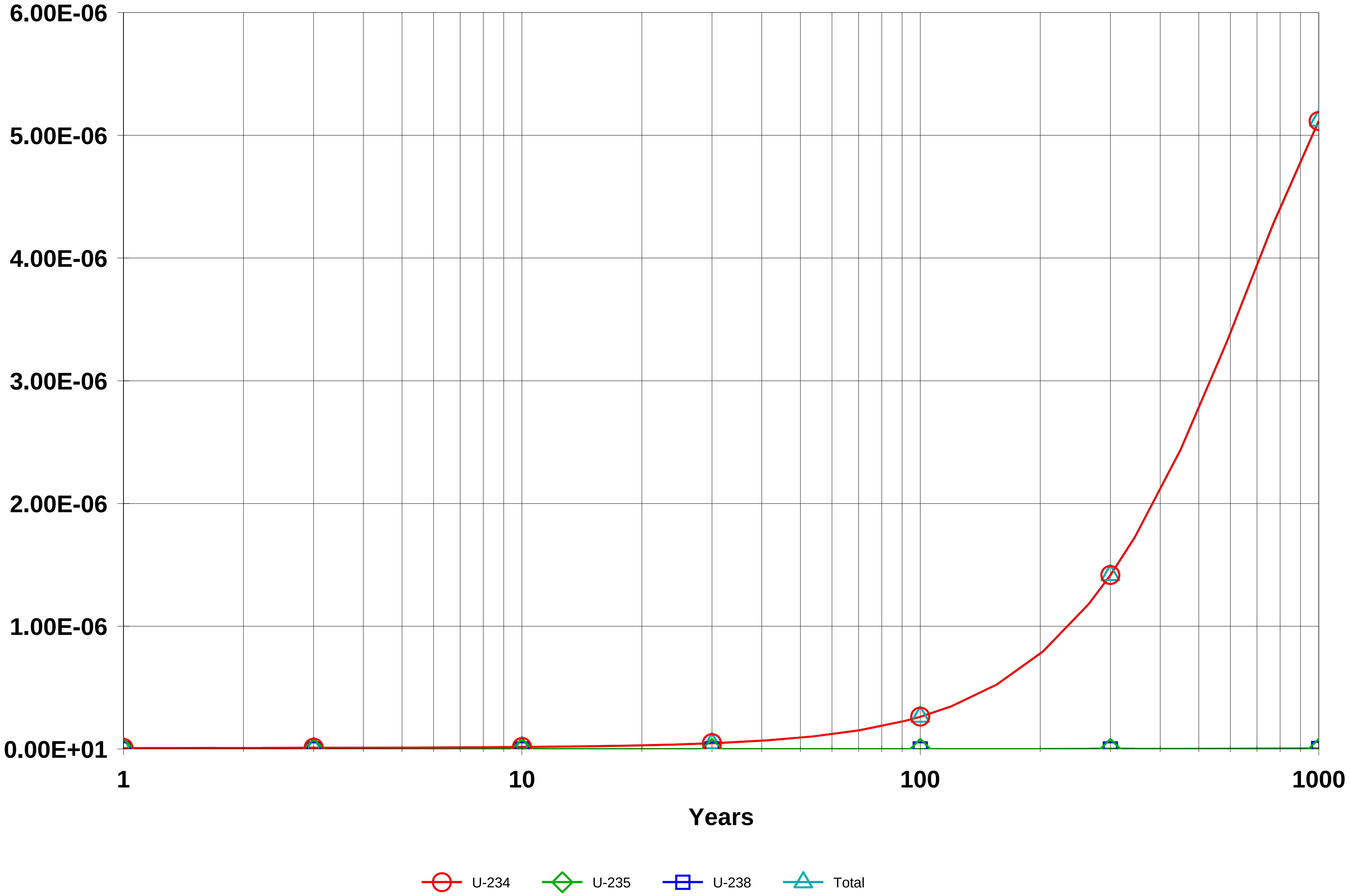


C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\HMC IRRIGATION FINAL RSE ADDENDUM.RAD 08/12/2010 13:04 GRAPHICS.ASC Pathways: Radon (Water Independent)



C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\HMC IRRIGATION FINAL RSE ADDENDUM.RAD 08/12/2010 13:04 GRAPHICS.ASC Includes All Pathways

EXCESS CANCER RISK: All Nuclides Summed, Radon (Water Independent)



C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\HMC IRRIGATION FINAL RSE ADDENDUM.RAD 08/12/2010 13:04 GRAPHICS.ASC Pathways: Radon (Water Independent)

Concentration of radionuclides in environmental media
at t = 1.000E+03 years

Radio-Nuclide	Contaminated Zone pCi/g	Surface Soil* pCi/g	Air Particulate pCi/m**3	Well Water pCi/L	Surface Water pCi/L
Ac-227	4.023E-04	4.023E-04	6.812E-09	2.487E-01	2.487E-03
Pa-231	5.023E-04	5.023E-04	8.504E-09	1.283E-01	1.283E-03
Pb-210	1.126E-02	1.126E-02	1.907E-07	2.153E-01	2.153E-03
Ra-226	1.222E-02	1.222E-02	2.069E-07	3.231E-01	3.231E-03
Th-230	1.140E-01	1.140E-01	1.929E-06	1.519E-03	1.519E-05
U-234	5.758E-01	5.758E-01	9.749E-06	1.470E+02	1.470E+00
U-235	2.399E-02	2.399E-02	4.062E-07	6.127E+00	6.127E-02
U-238	5.758E-01	5.758E-01	9.749E-06	1.470E+02	1.470E+00

*The Surface Soil is the top layer of soil within the user specified mixing zone/depth.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Concentration of radionuclides in foodstuff media
at t = 1.000E+03 years*

Radio-Nuclide	Drinking Water pCi/L	Nonleafy Vegetable pCi/kg	Leafy Vegetable pCi/kg	Fodder Meat pCi/kg	Fodder Milk pCi/kg	Meat pCi/kg	Milk pCi/L	Fish pCi/kg	Crustacea pCi/kg
Ac-227	2.487E-01	2.587E-01	1.237E+00	1.353E+00	1.353E+00	2.564E-03	2.288E-03	3.730E-02	2.486E+00
Pa-231	1.283E-01	1.383E-01	6.427E-01	7.038E-01	7.037E-01	2.726E-01	2.975E-04	1.283E-02	1.411E-01
Pb-210	2.153E-01	3.369E-01	1.183E+00	1.288E+00	1.288E+00	8.334E-02	3.329E-02	6.456E-01	2.157E-01
Ra-226	3.231E-01	8.278E-01	2.100E+00	2.248E+00	2.249E+00	1.751E-01	1.815E-01	1.615E-01	8.077E-01
Th-230	1.522E-03	1.157E-01	1.220E-01	1.237E-01	1.237E-01	6.557E-03	3.211E-04	1.521E-03	7.609E-03
U-234	1.470E+02	1.539E+02	7.319E+02	8.024E+02	8.022E+02	2.115E+01	4.076E+01	1.471E+01	8.823E+01
U-235	6.127E+00	6.412E+00	3.050E+01	3.343E+01	3.342E+01	8.812E-01	1.698E+00	6.127E-01	3.676E+00
U-238	1.470E+02	1.539E+02	7.319E+02	8.024E+02	8.022E+02	2.115E+01	4.076E+01	1.471E+01	8.823E+01

*Concentrations are at consumption time and include radioactive decay and ingrowth during storage time.
For livestock fodder, consumption time is t minus meat or milk storage time.

Concentrations in the media occurring in pathways that are suppressed are calculated using the current input parameters, i.e. using parameters appearing in the input screen when the pathways are active.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	7.737E-02	0.0059	7.239E-03	0.0005	6.443E-01	0.0489	1.684E-01	0.0128	5.379E-03	0.0004	6.062E-03	0.0005	8.831E-03	0.0007
U-235	1.088E-02	0.0008	4.023E-04	0.0000	0.000E+00	0.0000	7.317E-03	0.0006	1.039E-03	0.0001	1.174E-04	0.0000	4.834E-04	0.0000
U-238	4.937E-02	0.0037	4.355E-03	0.0003	3.444E-04	0.0000	3.377E-02	0.0026	1.114E-03	0.0001	2.727E-03	0.0002	4.241E-03	0.0003
=======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======
Total	1.376E-01	0.0104	1.200E-02	0.0009	6.446E-01	0.0489	2.095E-01	0.0159	7.532E-03	0.0006	8.907E-03	0.0007	1.356E-02	0.0010

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	4.302E-02	0.0033	5.108E+00	0.3877	2.087E-01	0.0158	5.439E-01	0.0413	6.821E+00	0.5177
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.846E-01	0.0595	9.841E-02	0.0075	2.242E-02	0.0017	9.256E-01	0.0703
U-238	0.000E+00	0.0000	0.000E+00	0.0000	4.827E-05	0.0000	4.653E+00	0.3532	1.780E-01	0.0135	5.014E-01	0.0381	5.429E+00	0.4120
=======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======	=========	======
Total	0.000E+00	0.0000	0.000E+00	0.0000	4.307E-02	0.0033	1.055E+01	0.8004	4.851E-01	0.0368	1.068E+00	0.0810	1.318E+01	1.0000

*Sum of all water independent and dependent pathways.

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Plant		Meat		Milk		All Pathways**	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	5.403E-07	0.0041	1.485E-09	0.0000	1.939E-09	0.0000	5.553E-07	0.0042
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	9.666E-08	0.0007	5.428E-08	0.0004	8.666E-11	0.0000	1.557E-07	0.0012
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	2.700E-06	0.0204	2.430E-07	0.0018	1.453E-07	0.0011	4.195E-06	0.0317
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	6.093E-07	0.0046	6.789E-08	0.0005	1.084E-07	0.0008	3.257E-06	0.0246
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	6.599E-10	0.0000	8.973E-12	0.0000	7.693E-13	0.0000	5.710E-08	0.0004
U-234	0.000E+00	0.0000	0.000E+00	0.0000	4.607E-05	0.3485	1.762E-06	0.0133	4.963E-06	0.0375	5.324E-05	0.4027
U-235	0.000E+00	0.0000	0.000E+00	0.0000	1.962E-06	0.0148	7.506E-08	0.0006	2.114E-07	0.0016	2.476E-06	0.0187
U-238	0.000E+00	0.0000	0.000E+00	0.0000	5.818E-05	0.4401	2.225E-06	0.0168	6.268E-06	0.0474	6.826E-05	0.5164
Total	0.000E+00	0.0000	0.000E+00	0.0000	1.102E-04	0.8333	4.429E-06	0.0335	1.170E-05	0.0885	1.322E-04	1.0000

** Sum of water independent ground, inhalation, plant, meat, milk, soil
and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of
Radon and its Decay Products at t= 1.000E+03 years

Radon	Radionuclides							
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	1.110E-06	2.182E-06	2.765E-06	5.409E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Water-dep.	7.531E-08	1.493E-07	1.893E-07	3.703E-07	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Total	1.185E-06	2.331E-06	2.955E-06	5.779E-06	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)
and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
U-234	1.767E-06	0.0122	3.738E-08	0.0003	1.146E-05	0.0793	2.049E-06	0.0142	6.612E-08	0.0005	6.766E-08	0.0005	9.033E-08	0.0006
U-235	2.189E-07	0.0015	1.300E-09	0.0000	0.000E+00	0.0000	1.872E-08	0.0001	1.077E-09	0.0000	1.160E-09	0.0000	2.089E-09	0.0000
U-238	1.037E-06	0.0072	2.447E-08	0.0002	6.158E-09	0.0000	4.252E-07	0.0029	1.403E-08	0.0001	3.434E-08	0.0002	5.339E-08	0.0004
Total	3.023E-06	0.0209	6.315E-08	0.0004	1.147E-05	0.0794	2.493E-06	0.0173	8.123E-08	0.0006	1.032E-07	0.0007	1.458E-07	0.0010

APPENDIX G – RESPONSIVENESS SUMMARY

Comment Responses, Draft RSE Addendum, Homestake Superfund Site, Milan, NM						
Comment Number	**Commenting Organization**	**Report Section**	**Report Page**	**Comment**	**Action**	**Response**
1	HMC	9.2	45	Recommendation No. 1 - The flushing of the tailings pile should be curtailed. HMC disagrees with this recommendation, and it should be removed from the final RSE report.	Non-concur	As stated in the RSE Addendum Report, though progress has been made in reducing concentrations in the monitoring points, there are questions about the representativeness of the samples in these wells due to the very long screened intervals, the volume of injected water relative to the volume present, and the lack of response in concentration in recovered water. Regarding the latter point, though the HMC comment suggests that a downward trend is present in toe drain concentrations, but if the data since 2002 is used, the downward trend is not apparent.
2	HMC	9.2	45	Recommendation No. 2 - Simplification of the extraction and injection system is necessary to better focus on capture of the flux from under the piles and to significantly reduce dilution as a component of the remedy. HMC believes this recommendation has some merit and plans to re-evaluate the existing system to possibly achieve more efficient mass removal of the constituents.	Noted	We are glad to hear a re-evaluation will be conducted.
3	HMC	9.2	45	Recommendation No. 3 - Further evaluate capture of contaminants west of the northwestern corner of the large tailings pile. HMC plans to assess the available injection/collection data, water levels, and chemical data in these areas and re-evaluate the effectiveness of capture system. Adjustments to the existing injection/collection system may be considered to achieve more effective capture.	Noted	

4	HMC	9.2	46	Recommendation No. 4 - If not previously assessed, consider investigating the potential for contaminant mass loading on the ground water in the vicinity of the former mill site. HMC is uncertain of the basis for this recommendation because demolition of the mill and cover of former mill area is well-documented. HMC does not believe that additional investigations of the mill area are necessary and the ACOE's recommendation should be removed from the final RSE report.	Non-concur	The RSE Addendum does not associate the elevated ground water uranium concentrations with the mill debris or other aspect of the former mill site. The ground water concentrations are noted as being higher in this area than in surrounding areas. This is circumstantial evidence of a source in this area, and we are simply suggesting this may be worth investigating to help achieve site goals.
5	HMC	9.2	46	Recommendation No. 5 - Further investigate the extent of contaminants, particularly uranium in the upper middle Chinle aquifers and resolve questions regarding dramatically different water levels among wells in the middle Chinle. It is unclear why the ACOE recommends further investigation of the Upper Chinle aquifer when it interprets the performance of remediation in the Upper Chinle aquifer to be adequate. HMC believes that the existing monitoring of the Upper and Middle Chinle aquifers is adequate from a site-wide perspective and for areas where constituent concentrations are greater than site standards.	Non-concur, in part	Based on the mapped extent of uranium in the Upper Chinle shown in the 2008 Annual Report, Figure 5.3-11, the 0.1 mg/L uranium is not constrained north of CE9 in section 35 or the southern part of section 26. There are no wells in the Middle Chinle north of the uranium plume shown in figure 6.3-11 of the 2008 Annual Report. Flow according to the arrows on the figure is to the north, though flow would be distorted by the injection into CW14. The RSE correctly identifies the disparate water levels (differing by over 100 feet in some cases) between nearby wells in the Middle Chinle, sometimes reflecting a gradient opposite that indicated by the arrows on the figures.
6	HMC	9.2	46	Recommendation No. 6 - Consider geophysical techniques, such as electrical resistivity tomography to assess leakage under the evaporation ponds. Fluid migrating out of the ponds would have very high total dissolved solids and are, therefore, highly conductive. However, the geophysical survey would not be able to provide any information on leakage rates and would therefore not provide useful information.	Non-concur	The identification of the migration of highly conductive fluids in the subsurface would at least be qualitative evidence of leakage. Repeated measurements showing temporal changes in the extent of such conductivity anomalies would allow estimation of volumes through modeling.

7	HMC	9.2	46	Recommendation No. 7 - Assure decommissioning of any potentially compromised wells screened in the San Andres Formation is completed as soon as possible HMC plans to review available borehole logs for San Andres Aquifer monitoring wells and identify those which have screens or gravel packs that extend up into the overlying Chinle Formation that could potentially allow from possible cross-contamination. Available water levels will also be reviewed to determine if a particular well's water level is consistent with other San Andres Aquifer wells.	Noted	
8	HMC	9.2	46	Recommendation No. 8 - Consider construction of a slurry wall or PRB around the site to control contaminant migration from the tailings piles. The decision for implementing such an alternative would depend on the economics of the situation. HMC has evaluated the economics and implementability of a slurry wall and PRB and found them to be impractical and cost-prohibitive remedial options given the difficulty of construction and likelihood of incomplete isolation or collection of the alluvial groundwater because of the excessive depth of excavations. The ACOE's recommendation for further evaluation of slurry walls and PRBs should be removed from the final RSE report.	Concur, in part	The recommendation will not be removed, **but the results of HMC's economic analysis will be noted** though no details are provided as to the assumptions and extent of the economic impacts analyzed (such as impacts on the treatment plant operational costs). The slurry wall was intended to be a suggestion to improve both likelihood of containment and a way to reduce costs for operations of the treatment plant.
9	HMC	9.2	46	Recommendation No. 9 - Relocation of the tailings should not be considered further given the risks to the community and workers and the greenhouse gas emissions that would be generated during such work. HMC agrees that relocation of the tailings should not be considered further. HMC also believes that it is important to re-emphasize that this "Alternative Strategy" would create a significant risk to human health.	Noted	

10	HMC	9.2	46	Recommendation No. 10 - If geotechnical considerations allow, consider expansion of the evaporation pond on the small tailings pile as means to enhance evaporative capacity. This has also been recognized by the State of New Mexico, with the recent approval of DP-725 for the construction of EP-3. In light of this, the recommendation to expand the evaporation pond on the small tailings is not appropriate. In addition, expansion would be difficult due to geotechnical considerations. The expanded pond would need to be tied into EP-1; this would pose a geotechnical challenge and would possibly compromise the liner system of EP-1.	Concur	**The RSE will be amended to remove this recommendation.**
11	HMC	9.2	46	Recommendation No. 11 - Consider either the pretreatment of high concentration wastes in the collection ponds as is currently being pilot tested, or adding RO capacity to increase treatment plant throughput and reduce discharge to the ponds. The RO treatment plant will be able to operate at its full potential, with the recent approval of DP-725, and additional RO capacity is therefore not needed in order to increase plant throughput.	Non-concur	It is still advisable to increase treatment plant throughput to minimize loading to the ponds
12	HMC	9.2	46	Recommendation No. 12 - Develop a comprehensive, regular, and objectives-based monitoring program. Quantitative long-term monitoring optimization techniques are highly recommended. HMC plans to evaluate the site groundwater monitoring program, which includes identifying and categorizing wells and their intended purpose, followed by evaluating each monitoring well and determining its inclusion or exclusion in the monitoring program. HMC plans to perform this procedure for those monitoring wells that are required under state permits or federal license.	Noted	Great. We can provide additional guidance on approaches if desired.

13	HMC	9.2	47	Recommendation No. 13 - Adjust Air Monitoring Program to perform sampling of radon decay products to confirm equilibrium assumption, consider use of multiple radon background locations to better represent the distribution of potential concentrations and assess the radon gas potentially released from the evaporation ponds, especially during active spraying. HMC does not believe that any adjustment to the air monitoring program is required with respect to the radon decay products as well as the evaporation ponds. HMC is evaluating the location of the radon background monitor, and will work with NRC on this evaluation.	Non-concur, in part	Concur that HMC should continue to work with NRC to evaluate the radon background location as described in the July-December 2009 Semi-Annual Environmental Monitoring Report. All other recommendations to confirm important air monitoring assumptions and improve sampling data presentation will remain in the report as modified in response to other stakeholder comments.
14	HMC	9.2	47	Recommendation No. 14 - Though risks appear minimal with the current irrigation practice, consider treatment of contaminated irrigation water via ion exchange prior to application as a means to remove contaminant mass from the environment. HMC requests that Table 5 and Table 6 be removed from Section 8.1.1 of the report because they were generated based on the irrelevant and misleading irrigation scenario as described above. HMC does not believe this would improve the current irrigation system, and would be technically infeasible to implement.	Non-concur	The intent of the analysis of treatment options for the irrigation water was to assess what would be required in order to address stakeholder concerns and EPA's preference for treatment. As noted elsewhere, additional treatment would be required beyond ion exchange for uranium, if the form of U in the ground water is non-ionic due to complexing with calcium carbonate. Initial ion exchange to reduce calcium concentrations would likely yield an anionic form of the uranium. This additional step would require regeneration of the resins and the resulting brines would need to be transported and disposed in the evaporation ponds. This may or may not be practical, and further analysis and testing would be required to verify the true treatment requirements, brine production, and cost.

15	HMC	EXSUM	ii	A conclusion is made that there may have been widespread impacts on the general water quality (e.g., ions such as sulfate) of the alluvial aquifer since mill operations began, but the limited amount of historical data precludes certainty in this conclusion. HMC believes that this conclusion is speculation, and the Grants site does not contribute to widespread impacts. The ACOE fails to recognize that there are several alluvial systems in the Grants vicinity. The San Mateo alluvial system underlies the site with contributing water-quality effects from the Rio San Jose alluvium to the west and the Lobo alluvium to the east. It is, therefore, the combination of water quality from each of these alluvial systems that may represent any potential widespread impact, and the Rio San Jose alluvium is known to have elevated sulfate.	Concur, in part	We are well aware of the complexities of the alluvial systems at the site. The text makes a statement of fact regarding the increases in sulfate concentrations. Note that the sulfate impacts do seem to emanate from the San Mateo drainage, based on maps of sulfate concentrations in the HMC 2008 Annual Report.
16	HMC	EXSUM	ii	A conclusion is made that the seepage modeling likely overestimates the efficiency of flushing of the tailings. HMC disagrees with this conclusion. Our review of the model predictions shows that the model reasonably matches observed conditions with a lag effect. This lag effect is due to reductions in extraction within the large tailings pile in recent years that was not envisioned nor included in the modeling effort.	Non-concur	The seepage modeling matches concentrations that have been impacted by preferential flow through wells and higher permeability materials.
17	HMC	1.1	1	A statement is made that leaching from the mill site has contaminated groundwater. HMC is unaware of any supporting documentation that the mill site has contaminated groundwater.	Non-concur	See response to HMC comment 4 above.
18	HMC	1.4	3	The previous RSE report is mentioned. HMC would like to point out that this previous report was flawed and had errors in its interpretations.	Non-concur	This RSE is not intended to render a judgment on the previous work. The statements in this section are factual and non-judgmental.

19	HMC	1.4.3	4	A statement is made that "*Data for samples collected in the 1950s from a couple of alluvial aquifer wells approximate 2.5 miles west of the site (well numbers 0935 and 0936) suggest significant increases in sulfate concentrations have occurred* ." These wells are in the Rio San Jose alluvium west of and unimpacted by the site. The inference in this section, however, is that the increasing sulfate in the wells may be due to the Grants site and it is not. Any observed increase in sulfate would be due to activities further west and upgradient of the wells.	Concur	See response to comment 15 above.
20	HMC	1.4.4	4	The extraction and injection system is stated to be not well documented. HMC disagrees with this statement. The system is sufficiently described in the annual groundwater monitoring report, which contains the volumes of water removed and injected, constituent concentrations of these waters, and maps showing the locations of system components.	Non-concur	The annual reports do provide a wealth of information about this complex site; however, the operational parameters (flow, pumping levels) for specific wells are not documented. It was not easy to assess the performance of the system because the system seemed to be constantly changing.
21	HMC	1.4.5	5	The RO treatment capacity is stated as 600 gpm and practical limitations are less than that. This is incorrect. The RO plant can be run at higher rates and, with the additional capacity provided by the third evaporation pond, can be operated at the 600 gpm rate or higher. The limitation is not in the clarifier section.	Non-concur	The USACE recorded in their notes at the site visit that there was a 600 gpm limitation on the clarifier. The USACE recorded this information from their site visit. If this is in error, the USACE will replace with what HMC believes to be the limiting RO plant treatment flow rate. **The text will be changed to indicate that a > 600 gpm flow rate through the current treatment plant is possible but that alternatives were developed using a 600 gpm (with allowance for change out of RO columns).**
22	HMC	1.4.6	5	A discussion of the evaporation ponds is presented, but is not complete. The ACOE does not mention that pond #2 has a double liner and pond #1 has a single liner. A third evaporation pond that has been approved by the NRC has just received approval from NMED.	Concur	**This information will be added.**

23	HMC	2.1.1	6	A statement is made that it is possible the uranium is not as accessible for dissolution, but it may slowly mobilize over time. The ACOE provided no basis for this statement, and our evaluations do not support it either (See HMC's response to Recommendation No. 1). This statement should be removed from the final RSE report.	Non-concur	The section actually notes the relative immobility of the uranium; however, the pH/Eh conditions in the pile are such that there is a potential for slight on-going mobilization of the U. This is based on Eh/pH diagrams for U with O, H2O, and CO2.G17
24	HMC	2.1.3	6	The ponds are stated as being a possible secondary source of contaminants affecting air, soil, and groundwater if the liners under the ponds were to leak. This statement is speculative and should be removed from the final RSE report.	Non-concur, in part	We agree that the statement is speculative, but it is true that if the ponds were to leak, they would be sources. **We will clarify that there is no current evidence of leakage.** HMC must acknowledge, though, that as engineered structures, these pond liners can fail. It is widely accepted that caps and liners have some very small but finite permeability due to imperfections in seams, tears, etc. There is no such thing as a perfect liner. We note that there have been instances where the exposed liners have had damage along the berms.
25	HMC	2.1.4	6	Irrigation with site water is stated as possibly affecting groundwater through leaching. This is contrary to the ACOE's finding in the draft RSE report that irrigation has not impacted groundwater. This statement should be removed from the final RSE report.	Concur, in part	We will clarify that there is no evidence for such impacts at this time and that the severity of the actual future impact is uncertain

26	HMC	2.2.1	7	It is stated that the air monitoring program at the Grants site attempts to quantify the radon in air pathway. HMC has actually gone to great lengths to "quantify" this pathway and has found that the measured radon at the site boundary primarily is from natural background sources, with only a small component originating from the site. In fact, the EPA issued a "no action" on Radon in the Record of Decision for Grants at a point in time when the tailings piles were open and the mill was still operating. This decision was based on a comprehensive study where radon concentrations were measured in nearby homes by an independent competent scientist. The tailings piles are now covered and the mill has been decommissioned so the on-site source has been greatly reduced.	Non-concur	EPA and NMED have identified significant stakeholder concerns with the current air monitoring program and requested that the RSE Addendum include an evaluation and recommendations. The Selected Remedial Approach in the 1989 Record of Decision included the following statement: "While EPA believes that continued subdivisions monitoring is unwarranted at this time, EPA recognizes the need to monitor outdoor radon and windblown particulate levels south of the disposal area to assure that conditions in the subdivisions do not significantly change prior to final site closure. In this regard, EPA will continue to review outdoor radon monitoring and particulates data collected at the facility boundary pursuant to NRC-license requirements. Should an increasing trend in either radon or particulates levels be noted, EPA and NRC will require monitoring or corrective action In the subdivisions, whichever Is appropriate."
27	HMC	2.3	7	The text incorrectly refers to Figure 1 as the conceptual site model. The conceptual site is shown on Figure 2. HMC believes that the conceptual site model is flawed. As discussed in our response for Recommendation No. 4, HMC does not believe that the former mill area is a "Primary Source," as depicted on the conceptual site model. Additionally, several of the exposure pathways that are indicated as complete are actually not complete. An example of this is the incomplete groundwater drinking pathway for a trespasser, resident, or worker, currently and in the future. We suggest that the ACOE reexamine this conceptual site model before issuing the final RSE report.	Non-Concur, in part	The **reference to the CSM Figure will be corrected**. The CSM sources and pathways will be reevaluated based on this and other stakeholder comments and the information compiled by HMC in the annual Land Use Review/Survey. The **descriptions and figure will be clarified** to better indicate known sources, receptors and transfer pathways and potential sources, receptors, and transfer pathways.

28	HMC	3.2	13	The ACOE cites well 0882, located south of the wells used for irrigation in the northern plume, as providing evidence for incomplete capture because uranium concentrations have increased. However, the increase is only on the order of 0.02 mg/L and within typical variability of uranium concentrations in the alluvial aquifer in this area. The uranium concentration is below the site standard and below the maximum contaminant level, and the slight increase is not an indicator of incomplete capture.	Non-concur	The concentrations measured in well 882 have a systematic rise in concentration over 13 years and has tripled in concentration. The data do not suggest the increase is related to analytical "variability"
29	HMC	3.2	15	Well DD is discussed and the uranium concentration in the well is speculated to be a result of migration from the tailings pile. Well DD is an approved background well and the 95 percent confidence limit of uranium concentrations in the well were used to set the site standard for the alluvial aquifer. It is highly unlikely that groundwater is flowing to the north because the water level in well DD is several feet higher than at the tailings pile. Furthermore, the uranium concentration has consistently been near the 0.16 mg/L site standard level since 1995, indicating a steady source of uranium from upgradient areas, whereas the uranium concentration at the tailings pile has been decreasing over this period. If the tailings pile was the source of uranium in well DD, one would expect the uranium concentration to decrease to some degree because of the decreasing concentrations at the tailings pile, but this has not occurred.	Concur	The report text essentially agrees with the HMC comment. We do not attribute the concentrations in well DD to leakage from the tailings. No changes are required to the report.

30	HMC	3.4	15	It is stated that the model likely over-predicts the performance of tailings flushing. A similar statement is made in the Executive Summary. HMC's review of the model predictions shows that the model reasonably matches observed conditions; however, there is a lag effect. This lag effect is due to reductions in extraction within the large tailings pile in recent years that was not envisioned nor included in the modeling effort.	Non-concur	See response to comment 16
31	HMC	3.6	16	It is stated that the flow direction in the San Andres aquifer is to the northeast. However, the flow direction is toward the east and lightly southeast, as shown on Figure 8.0-1 of the 2008 Annual Monitoring Report (HMC and Hydro-Engineering, LLC. 2009).	Concur, in part	The northeasterly flow was based on water levels in March 2009, as provided in the data base. **The text will be revised to note the easterly to southeasterly flow in 2008.**
32	HMC	4	17	The ACOE states that "According to Homestake, flushing of the tailings pile will be completed by 2012, with the remaining groundwater contamination completed by 2017." The last part of the sentence is worded in an awkward manner; it should read "…with remediation of the remaining groundwater contamination completed by 2017."	Concur, in part	**Change will be made to read as suggested.**
33	HMC	4	17	The ACOEs states that "…potentially applicable replacement technologies are discussed…." Two of the possible strategies, slurry wall and PRBs are discussed. Each of these technologies is technically impracticable (see HMC's response to Recommendation No. 8). The ACOE actually provides no replacement technologies that have not already been considered.	Non-concur	Though challenging, based on discussions with vendors it appears these alternatives are technically feasible. The report acknowledges there are questions about the economic advantages to implementation of these approaches compared to current approaches, particularly since a portion of the site would be underlain by permeable bedrock units.

34	HMC	4 & Fig. 14	17	The flushing of the large tailings pile is discussed and Figure 14 is used to show the 2008 uranium concentrations in the tailings. Although the ACOE uses this figure to show the variability of uranium in the pile and illustrate their belief that the flushing has not been effective, HMC believes that the flushing has been effective at removing uranium mass. This is demonstrated by comparing the 2000 and 2009 maps for uranium in the tailings pile, which shows that a significant amount of uranium has been removed. See also HMC's response to Recommendation No. 2 for additional evidence of the effectiveness of the flushing and extraction program. Below is the 2000 uranium concentration map for the tailings pile showing uranium concentrations exceeding 30 mg/L in much of the pile. Also below is a map of the 2009 uranium concentrations in the pile, which illustrates the significant reduction in concentrations resulting from the flushing and extraction program. For 2009, approximately 67.5 percent of the west side slime area has uranium concentrations less than 5.0 mg/L, and 45.5 percent of the same area has concentrations lower than 2.0 mg/L.	Non-concur	The flushing program has made some progress, as the report acknowledges. As discussed above and in the report, the concern is that the long screens of the monitoring points makes it likely that injected water has impacted the monitoring point, but that the ambient concentrations may much different. The map was meant to illustrate the wide variations in concentrations at closely spaced points such that the flushing is clearly not uniform.

35	HMC	4.1	19	The ACOE presents a calculation of the volume of water within the tailings and bases the volume on a total porosity of 30 percent, which is not substantiated or appropriate. The mobile porosity (i.e., effective porosity) of the tailings should have been used. The slimes may have a total porosity of around 30 percent, but the effective porosity is more on the order of 8 percent and 14 percent for the tailing sands. The result of this is that the ACOE has most likely overestimated the volume of water in the tailings, which correspondingly underestimates the success of the flushing and extraction system. HMC estimates that approximately one pore volume has been flushed from the tailings.	Non-concur	The total porosity is of interest. Though it is agreed that the effective porosity is applicable for assessing the flushing of the actual pathways, the real goal here is to remove uranium-rich pore fluid. Note that the "immobile" pore space contains contaminants that will diffuse back into the mobile porosity over time and will likely cause rebound in concentrations. In addition, HMC does not account for the leakage of injected fluids via the long open intervals in the wells.
36	HMC	4.1	19	A calculation is made of the natural groundwater flow in the alluvial aquifer beneath the large tailings pile, which is substantially overestimated. Based on site data, the hydraulic conductivity of the alluvium used in the calculation should be about 20 feet/day, not 80 feet/day. The gradient of 0.008 is high and should be lower near approximately 0.003. HMC's estimate of the natural flow in the alluvial aquifer is in the range of 60 to 80 gpm, not 450 gpm as estimated by the ACOE. Consequently, the amount of alluvial groundwater that needs to be captured beneath or surrounding the large tailings pile is considerably less than what is estimated by the ACOE.	Non-concur	The hydraulic conductivity used in the analysis was within the range of values (10-800 ft/day) given in the report on site modeling, though conservatively higher than the "typically 30-60 ft/day" cited in Table 1-1 of that report. The gradient was estimated from site water levels west of the treatment plant, and, again is estimated conservatively high. The intent of the calculation was to estimate a conservatively large value for the flux for assessing the treatment needs. If the flux is truly only 60-80 gpm, then the flushing and reinjection is requiring the plant to treat as much as 3-5 times more water than necessary.G103

37	HMC	4.2	19-20	The ACOE states that injection of relatively clean water from other aquifers into the alluvial aquifer may do more to dilute the plume than treat it. However, injection of water has demonstrated to be an effective technology for plume control, and in addition to controlling the plumes, injection is often necessary to sustain a sufficient saturated thickness in the alluvial aquifer to enable extraction to occur; otherwise the aquifer would be dry. An example of this is at Felice Acres, where injection into the alluvial aquifer occurs. Initial extraction wells in this area yielded very little water and wells commonly became dry when pumped. With injection, a sufficient saturated thickness is maintained that enables uranium and other constituents to be collected. Without injection little or no constituent mass would be extracted.	Non-concur	We agree the injected water increases saturated thicknesses and improves performance of the extraction wells. However, the injection of significant amounts of clean water clearly has an impact on concentrations. It is not readily apparent that there is a water balance between injection, natural flux, and pumping in all areas, especially in the western portions of the plumes. The recirculation of injected water into the extraction system also increases volumes of water needing treatment, raising costs for operations.

38	HMC	4.2	19-20	The ACOE also states that extraction from the Upper Chinle draws water downward from the more contaminated alluvial aquifer. The only area where this could possibly occur is in the collection pond area where there is an approximate 500-foot wide zone of saturated alluvium overlying the Upper Chinle Aquifer, and extraction in the Upper Chinle Aquifer occurs in this area. However, HMC does not believe that pumping from the Upper Chinle Aquifer in this limited area is drawing contaminants downward as the following explains. The two most important parameters that control the movement from one aquifer to another are the head in the driving aquifer and the vertical hydraulic conductivity of the materials that the water has to move through between the two aquifers. In the collection pond area, the head in the alluvial aquifer would have to be substantially higher than the head in the Upper Chinle Aquifer and the materials would have to be highly permeable. Review of the 2008 water levels in the two aquifers in this area reveals that there is minimal head difference...	Non-concur	Based on comparison of water levels in October, 2008 in alluvial wells near the area of pumping in the Upper Chinle (south of the Collection Ponds), there is a downward gradient. Water levels in the alluvial aquifer are between 6530 and 6535 ft msl and water levels in the Upper Chinle, as shown on Figure 5.2-1 of the 2008 Annual Report are below 6530.
39	HMC	4.4.3	27	The ACOE suggests that a relatively new immobilization technology, still in lab development, be examined. The reference given is to "Frysell et al., 2005." This citation is incorrect; it should be Fryxell et al., 2005 (as noted correctly in Section 10, References). The referenced work involves the use of self-assembled monolayers on mesoporous supports (SAMMS), and as indicated by the ACOE, this is experimental and currently confined to the laboratory bench.	Noted	Comment noted (experimental, confined to lab bench), Frysell, et al., 2005 will be changed to Fryxell, 2005.

40	HMC	5.3	30	The ACOE states that ion exchange resin cannot reliably remove the cation form of selenium, selenite. Selenium will not be present as a cation in the groundwater. Selenium typically is found as selenate (SeO_4^{2-}; with selenium in the +6 oxidation state) or selinite ($HSeO_3^-$ or SeO_3^{2-}; with selenium in the +4 oxidation state) depending upon pH. All of these forms of selenium are anionic.	Concur	**Text will be modified.**
41	HMC	6.2	32	An evaporation rate reduction of 50 percent in the ponds is cited. However, HMC's research has found that the reduction rate is lower at approximately 10 percent (Salhotra et al. 1985) for the salinity present in the evaporation ponds.	Concur, in part	From the brine and fresh water plots from M. Al-Shammiri "Evaporation rate as a function of water salinity", Desalination 150 (2202) 182-203, a freshwater evaporation rate of approximately 120 gpm was inferred, with an approximate reduction of 50% from fresh water to saturated brine to 62 gpm. HMC cites a reduction of 10% based on Salhotra et al. 1985. The reduction of evaporate rate is not as important as actual passive evaporation rate from the ponds, which was supplied by Homestake in the USACE site visit as 80 gpm. The text will be revised to indicate that the actual % reduction of evaporation rate varies significantly in the literature (10-50% in the two studies referenced). The text will remain the same, though, indicating that use of the ~50% reduction rate from the Al-Shammiri study yields an approximate evaporation rate for the brine of 62 gpm, which compares to the passive rate of evaporation measured by Homestake of approximately 80 gpm. **The text "The slightly higher measured evaporation is most likely due to pond water, particularly at the surface, not being completely saturated." shall be removed.**
42	HMC	7.2.4	38	The ACOE provides details of improvements to the presentation of data in the air particulate laboratory reports. HMC has followed the standard reporting format required by NRC for the laboratory reports.	Non-concur	Current NRC Guidance, including Regulatory Guide 8.30, requires that results less than the LLD be reported, even if negative. However, **the report will be revised** to indicate that the laboratory data sheets in the July-December 2009 SAEMR no longer use <LLD values.

43	HMC	9.3	47	The ACOE provides a list of six recommendations that should proceed independent of any other recommendations. HMC's view on each of these recommendations and how to proceed are discussed in our responses as identified below: 1) the evaluation of the potential escape of contaminants at the northwestern portion of the site (see Response to Recommendation No. 3) 2) the evaluation of the former mill site as a potential source of groundwater contamination (see Response to Recommendation No. 4) 3) further characterization of the extent and migration of the Chinle plumes (see Response to Recommendation No. 5) 4) complete decommissioning of potentially compromised San Andres wells (see Response to Recommendation No. 7) 5) development of a comprehensive optimized monitoring program (see Response to Recommendation No. 12) 6) implement treatment of contaminated irrigation water to remove contaminant mass from the environment (see Response to Recommendation No. 14)	Noted	See other comment responses.
44	NMED	1.1.2	1	Assessment of the adequacy of the Site monitoring network (bullet #5) should also include evaluation of wells to monitor the delineation between saturated and unsaturated conditions in the alluvium, with emphasis on the potential for contaminants to migrate from the southernmost alluvial contaminant plume without detection.	Concur	**The report will note the need to include a comparison of measured water levels to the adjacent inferred top of rock surface to assure the plume is adequately defined**.

45	NMED	1.4.3	4	Site contamination of concern for which ground water remedial goals have been established include nitrate, chloride, and vanadium. NMED notes that interpretation of nitrate data may be complicated by agricultural activities that occurred prior to and during legacy uranium activities in the area.	Concur	**Section will mention these contaminants.** The report noted that there were other contaminants of interest not listed.
46	NMED	1.4.3	4	The second to last sentence in the first paragraph compares alluvial ground water data from 2.5 miles west of the site to alluvial ground water data and the site to demonstrate degradation of ground water quality. This is not an appropriate comparison as the alluvial ground water data taken west of the site is representative of San Jose alluvial water, whereas the data for the site is San Mateo alluvial ground water.	Concur	Though the statement of fact does not directly attribute the increase in sulfate to Homestake, it does imply this. **A clarification will be made that the cause of the increase is not clear**
47	NMED	1.4.3	4	The first sentence in the second paragraph should read "Water within the tailings piles..."	Concur	**Change will be made to read as suggested.**
48	NMED	1.4.6	5	Note that EP-2 construction included a double liner with leak detection	Concur	**Text will be revised**
49	NMED	2.1.2	6	Another possible explanation for elevated contaminant concentrations in the "1" series wells could be the result of a concentration gradient.	Noted	The nature of the "gradient" mentioned in the comment is not clear. Presumably, they were suggesting a gradient from the tailings pile. This is a possibility and the text will be revised to mention this. There is little recent data for wells between the mill site and the tailings pile. Well TB had approximately 0.8 mg/L Unat in 2005, a lower concentration than some of the I series wells.
50	NMED	2.1.3	6	Please qualitatively evaluate potential ecological risks from the use of uncovered evaporation and collection ponds.	Non-concur	The evaluation of potential ecological risks of evaporation pond usage is outside of the scope the focused review. The July 2008 Environmental Assessment completed by the NRC for EP3 included Section 4.1.5 discussing potential ecological impacts from the use of the evaporation ponds.

51	NMED	2.2	6-7	Although the surface water pathway is not complete, periodic flooding due to heavy rainfall does occur. Furthermore, one conclusion in this report is that contaminant source waste materials (i.e., the tailings piles) should remain on-site. Therefore, NMED herein reiterates an earlier comment from the discussion of the scope of work for this study that review of flood control structure constructed for the long-term protection of the tailings piles must be included within the RSE.	Noted	We defer to the agencies. Though such a study may be appropriate, it is beyond the scope of this RSE effort.
52	NMED	2.2.3	7	Although alternative water sources (i.e., hookups to the Milan municipal water supply) have been offered to current residents within the area of concern, which NMED has defined based upon the surface areal extent of Site-derived historical ground water contaminant plumes, there are currently no mechanisms either to require such hookup for current or future residents, nor to preclude the use and installation of private wells within this area. Additionally, current monitoring for potential site-derived impacts to the San Andres aquifer is inadequate to document long-term protection of this aquifer. For these reasons, NMED does not agree with the assertion that the ground water pathway is incomplete.	Concur	Based on information in the 2009 Annual Groundwater Monitoring Performance Review Report, Appendix E, Land Use Review/Survey, five residential properties remain to be provided a hookup as of March 31, 2010. We would encourage the continuation of periodic assessment of water usage, as required by HMC's NRC license and the testing of San Andres wells. See also response to Comment 27.
53	NMED	2.3	7	The last sentence should refer to figure 2 instead of figure 1.	Concur	**The text will be corrected.**
54	NMED	3.2	8	Please move x-axis label to the bottom of figures 3, 4, and 8.	Concur	**The readability of the charts will be improved in several ways.**

55	NMED	3.6	16	The San Andres aquifer is an important municipal water supply source to the nearby major population centers of Grants, Milan, and Bluewater, as well as to residents using private wells within the impacted subdivisions south of the site. NMED asserts that routine and focused monitoring of this aquifer, both upgradient and downgradient of the site, should be included within the Remedial System to better support an assertion of no contaminant impacts to this aquifer from the overlying site-contaminated aquifers.	Noted	We agree the San Andres is valuable resource that needs to be protected. Based on the available information in the annual reports, a number of San Andres wells are included in the monitoring program, including 1 upgradient well and 9 downgradient wells. If there are specific additional San Andres wells that NMED is aware of that should be included, we can note that in the report. In evaluating a comment from Milton Head, it was noted that a couple of monitoring points, 0943 and 0951, in the San Andres may have an increasing U concentration trend. The cause for this is not known.
56	NMED	4.1	17	The RSE team's argument for the discontinuation of the Large Tailings Pile ("LTP") flushing appears to be incomplete. NMED suggests that trends of contaminant concentrations in effluent discharged to the collection ponds should be evaluated and cited. Additionally, the heterogeneity of the LTP materials could indicate that some portion of uranium concentrations that do not respond to flushing (e.g., contaminants within slimes and other fine-grained materials) mostly will remain in-situ, and therefore, may not significantly impact alluvial ground water quality after flushing of the more-accessible and mobile contaminant concentrations within the LTP meets the flushing effluent objective. The RSE team might consider whether 1) continued flushing with reducing and/or low-alkalinity solutions to "fix" remaining accessible contaminants in-situ, and/or 2) deployment of an impermeable or an evaporative cover to the LTP, could reduce additional contaminant leaching from the LTP once draindown is complete.	Concur, in part	We agree that fluids that remain following years of flushing likely represent the less permeable materials. These materials are likely to release pore fluids much more slowly than the sandy material in the pile, but may still release contaminated fluids over time if water head is not reduced. Regarding the use of reducing and low alkaline solutions for flushing, such techniques are similar to the concepts evaluated in the RSE report for the soils below the pile. There would be a need to show that geochemical changes would be permanent, i.e. conditions would not revert to original conditions over time, with increased dissolution of uranium and selenium. **We will add this concept to the text in section 4.4.3, though will not specifically estimate costs for this.**
57	NMED	4.1	18	Tailings in Figure 15 is misspelled.	Concur	**Chart heading will be corrected.**

58	NMED	4.1	19	The RSE team did not document evaluation of possible alternatives to flushing of the LTP. Please provide and evaluation of possible alternative actions, including a comparative analysis of pump-and-treat at the toe of the LTP during draindown, in-situ immobilization technologies, and any other applicable alternatives.	Concur, in part	**As stated above, mention of immobilization of materials in the pile will be qualitatively added to section 4.4.3.** The RSE team still believes the dewatering and covering of the pile, as originally planned, represents a better end state for the pile.
59	NMED	4.1	19	The second sentence in the second paragraph on page 19 should acknowledge that draindown of the LTP may take decades.	Concur	**Text will be added.**
60	NMED	4.1	19	The last paragraph appears to assume a trend of decreasing contaminant concentrations after LTP flushing is discontinued. While flow rates would likely decrease over time due to termination of flushing, the RSE should address the possibility that contaminant concentrations in ground water may increase.	Concur	**This possibility will be noted in the last paragraph of section 4.1.**
61	NMED	4.2	19-20	The last sentence of the first paragraph on page 20 recommends injection of fresh water into the Chinle to reverse the recharge (contamination) from the alluvium to the Upper Chinle. NMED recommends that the RSE team evaluate the possibility that this action may exacerbate migration of contamination in the Upper Chinle.	Concur	**The text will be amended to note the risks of loss of control of the contamination in the Upper Chinle if injection is implemented improperly.**
62	NMED	4.3	20-23	The reliance on "existing liner (sic) under pond wastes" for long-term waste isolation may be inappropriate due to the observed and presumed deterioration of these mostly single liners over the ponds' usage period. Additionally, NMED recommends that the RSE team define the term "highly effective cap" within the context of long-term waste isolation.	Non-concur	The observed deterioration of the liners is most likely related to the exposure of the liner along the pond berms to sun and traffic of various kinds. The continuously submerged portions of the liners (that are also covered by precipitates) would not be subjected to the same conditions. The report does acknowledge the potential for leakage of the liners and suggests a method to assess leakage.
63	NMED	4.3	20-23	No alternative methods of evaluation were discussed to determine of ponds were leaking other than investigative methods.	Noted	The RSE team does not have other methods to suggest.

64	NMED	4.4.1	23	The proposal for deployment of slurry walls does not address the long-term objective to achieve ground water protection standards through establishment of stable, self-sustaining site conditions without ongoing maintenance requirements. NMED recommends that the RSE team attempt to quantify the length of time and associated costs for such maintenance as would be required under this proposal, in the same manner that the proposal for permeable reactive barrier emplacement is evaluated in the section following the discussion of this option in the report.	Concur, in part	There will be monitoring required to assess the slurry wall performance over time, but maintenance is negligible. **The text will note the need for monitoring of water levels**, but the cost for this is not significant. Slurry walls are generally considered to be very long-term components of a remedy.
65	NMED	4.4.3	25	As noted above, the RSE team might evaluate whether in-situ immobilization technology could be appropriate to LTP flushing.	Noted	Several types of in-situ immobilization technology was evaluated by the RSE team and found to be infeasible because of the large variation of pH at the site, which creates a different and diverse set of uranium ionic species for which stabilization treatment conditions have not been established. The cost to implement was also pointed out as a barrier. However, in-situ mobilization is currently occurring for the selenium, and to a more limited extent, by the current flushing regime where the reinjected water becomes reducing from passing through the residual slime in the LTP. The effect of the more reducing conditions is removal of the selenium, and potentially some of the uranium, from the groundwater. However, this in-situ mobilization may not be permanent when the flushing is stopped as more oxidative groundwater movement through the LTP may make the aquifer matrix more oxidative, with a resultant remobilization of the selenium and uranium. **This language will be added to the text.**
66	NMED	4.4.4	27	For consistency, the RSE team should employ similar AFCEE sustainable Remediation Tool analysis of other proposed remedial options.	Concur	This comment was addressed in a special addendum issued in June, 2010.

67	NMED	6.3	32	The original RSE report identified persistent operation and maintenance issues affecting the operation and maintenance of the evaporative sprayers. NMED recommends that the RSE team examine whether any different equipment and/or deployment strategies are available that could address these issues to enhance evaporation.	Noted	The team did not assess alternative equipment.
68	NMED	6.3	33	The last paragraph states 180 gpm as the proposed flow of wastewater into the evaporation ponds for disposal. This flow assumes the L TP flushing program is discontinued, but does not account for flows from the toe drain collection wells.	Non-concur	The analysis assumes that 65 gpm will be derived from the drains/sumps.
69	NMED	7.1.1	34	Documentation of the protection of the San Andres aquifer from impacts derived from the overlying contaminated aquifers should be an important component of the overall monitoring strategy for the Site.	Noted	The current RSE addresses the status and risk to the San Andres. The primary risk is through improperly completed wells. The report encourages the proper decommissioning of unused San Andres wells within the footprint of the plumes.
70	NMED	7.1.2	35	An important component of a critical re-evaluation of Homestake's monitoring system should be appraisal of each monitor well's completion documentation and current condition to ensure that samples from each well accurately reflect the ground water quality within the aquifer that is presumed to be monitored.	Noted	Such a well-by well evaluation of such an extensive network of monitoring wells is beyond the scope of this RSE. In some cases, the screened intervals of the wells were noted as part of the analysis, and the impact of this information was considered, as was the case with the wells in the large tailings pile.
71	NMED	7.1.2	35	Additional monitoring wells located at the confluence of the San Mateo and Rio San Jose alluvial systems to monitor the stability of ground water conditions within the alluvial aquifer should be considered.	Non-concur	There are a number of alluvial wells located in this area, though not many are sampled. Periodic but infrequent monitoring of additional available wells in the western portion of the study area may be appropriate.
72	NMED	8.1.1	40	The RESRAD modeling should be updated with current data which indicates contaminants have migrated in the irrigated soils well beyond 1 meter vertically.	Concur	The **RESRAD inputs will be reevaluated i**n response to this and other stakeholder comments. Specifically, the depth of contamination will be estimated using Figure 3-14 from the HMC 2009 Annual Irrigation Evaluation.

73	NMED	8.2	42	It must be noted that the New Mexico Water Quality Control ground water standard for selenium is 0.05 mg/l, not 0.12 mg/l.	Noted	**The report will be revised** to clearly indicate that the 0.12 mg/L was a site-specific selenium value based on background and that the current NMWQC standard for ground water is 0.05 mg/L. See also, NRC Comment 117 below on the application of water quality standards to irrigation water.
74	EPA	General		Considering the scope of work, time and budget constraints, the USACE has done a commendable job in evaluating this complex site and provided some practical recommendations.	Noted	Thank you
75	EPA	General		The report is well written and addresses the issues at length that were important to the stakeholders.	Noted	We certainly tried.
76	EPA	General	11-15, 18, 19, 21, 22	The graphs in the report should be reformatted, especially the x and y axis descriptions to better illustrate the data trends.	Concur	**The charts will be improved**
77	EPA	General		Include additional figures wherever possible to show location of wells for better understanding of the remedial system.	Concur	**Figures added where we could**
78	EPA	3.4	15-16	I agree with concern about the modeling approach for projecting uranium (and other contaminant) concentrations in the Large Tailings Pile (LTP) water under the currently implemented and projected flushing strategy. In line with the recommendation to curtail the current flushing operation, I recommend implementing a pilot test prior to 2012 to examine the potential for contaminant concentration rebound as a result of the cessation of flushing.	Concur	**We agree a pilot test would be an important contribution to our understanding of the long-term conditions in the pile and will add this to our recommendations.**

79	EPA	4.2	20	With regard to aquifer solids, clays and oxyhydroxide minerals are commonly the primary solid components to which metals and radionuclides will partition within the alluvium. Existing information on sorption characteristics of the impacted alluvium may be available through analysis of information presented in ATTACHMENT A - ALLUVIAL AQUIFER RETARDATION AND DISPERSION TEST RESULTS (GROUND-WATER MODELING FOR HOMESTAKE'S GRANTS PROJECT, Hydro-Engineering, L.L.C., April 2006).	Concur	**Will add discussion based on the attachment.**
80	EPA		36	I recommend caution with regard to the suggestion of "no-purge sampling" as an option for metals/radionuclides sampling from the HMC network of wells. If this recommendation is pursued, I recommend that a comparison of analytical data first be conducted for a subset of site wells prior to switching to this type of a sampling device. I would anticipate for collection of metals/radionuclides samples the accumulation of mineral precipitates within the well casing that may be dislodged and entrained within the sampler. One diagnostic to determine if this condition exists for well screens at the HMC Site is to periodically pull up and examine dedicated sampling devices, e.g., flexible polyethylene/teflon tubing or in -well pumps. If there are precipitate coatings on the device at the depth of the well screen, then I would be cautious about using a no-purge sampling device.	Concur	**We will add these cautions to the text.**
81	EPA		i-iv	Be consistent with the use of periods at the end of bulleted sentences/phases. Some sentences/phases have periods while other do not.	Concur	**Text will be revised.**
82	EPA		I	Add "with the current remedial strategy" to the end of the sentence.	Concur	**Text will be revised.**

83	EPA		I	3rd paragraph, sentence beginning with "The analysis…". Change "**at** the USACE EM CX" to "**by** the USACE EM CX".	Concur	**Text will be revised.**
84	EPA		v-vii	Be sure to align page numbers to the right. Currently numbers are scattered across pages.	Concur	**Text will be revised. The text alignment was apparently altered in the conversion to Acrobat format and wasn't noticed until it went out.**
85	EPA		2	Substitute "Robert Ford" for "Michele Simon". Michelle is no longer involved in the project.	Concur	**Text will be revised.**
86	EPA		5	Please update the last statement on page 5 regarding the approval of the new evaporation pond on the north side of the LTP. NMED has recently approved the discharge permit for the new evaporation pond.	Concur	**Text will acknowledge this.**
87	EPA	2.2.1	7	first sentence. Change 'human' to humans"	Concur	**Text will be revised.**
88	EPA	2.2.2	7	first sentence. Change 'and' to 'can'.	Concur	**Text will be revised.**
89	EPA	Figure 1	9	Add a figure that clearly indicates monitoring well locations. I can not identify monitoring wells referenced in the report on this figure.	Concur	**We will attach a separate file in 11x17" format such that it can be more easily read.**
90	EPA	Figures	11	Please check the labels on the x and y axes – the dates and other units are not correctly located or easy to read. Please reformat figures to allow for accurate reading of the x and y values.	Concur	**Text will be revised.**
91	EPA		17	last paragraph, 3rd sentence. Change 'has' to 'have' and change figure to "Figure 15 in the same sentence.	Concur	**Text will be revised.**
92	EPA		18	paragraph in the middle of the page regarding additional testing of oxidation-reduction potential. Please elaborate on the types of add'l testing that would be necessary and how the data should be interpreted.	Concur	**We will elaborate to indicate that downhole ORP and pH measurements would be useful to assessing the likely state of the U in the pile and the impacts from the flushing program on the stability of the U.**

93	EPA		19	2nd paragraph. Please clarify the "average saturated thickness" mentioned regarding the calculation of natural flow. Please include the thickness of the various aquifers at least by reference.	Concur	**Text will be revised.**
94	EPA		20	2nd paragraph. Please add information regarding how the boundary for active pumping vs. natural attenuation should be determined. Please discuss the need to use modeling or other lines of evidence to help quantify this boundary. Currently, the statement regarding use of the current extraction wells as the cut off point between capture and natural attenuation seems arbitrary.	Non-concur	The text indicates that the wells are near the limit of the plume defined by the 0.16 mg/L concentration and in good locations for capturing the plumes.
95	EPA		20	3rd paragraph. Please elaborate on the types of additional study required to assess unusual water levels.	Concur	**Additional discussion regarding the possible considerations, such as the examination of hydrographs, verification of top of casing elevations, assessment of transcription error in field notes.**
96	EPA		21	1st paragraph. Has it been confirmed that the 100 foot error in the C series wells is in fact in error or are you assuming that it is an error?	Noted	HMC comments indicated that this measurement was an error that has been corrected.
97	EPA		23	1st paragraph. Double periods at the end of the paragraph.	Concur	**Text will be revised.**
98	EPA		23	2nd paragraph. Double periods at the end of the first sentence.	Concur	**Text will be revised.**
99	EPA		23	Table 1. Please create table with gridlines and align numerical values left or right. Currently I believe they are centered and it is awkward to read. – same goes for Table 2 on page 25.	Concur	**Text will be revised.**

100	EPA		iii	In the recommendation on slurry wall construction, USACE should consider deleting the last sentence "The decision for implementing such an alternative would depend on the economics of the situation" or adding additional clarification. It is not clear why only this alternative would depend on the economics and not the others.	Non-concur	The primary benefit of the slurry wall would be to reduce the amount of pumping necessary to prevent lateral or vertical contaminant migration. As noted in the report, the presence of permeable bedrock below a portion of the alignment/pile would require some pumping to prevent migration. If pumping and treatment are still needed, the capital cost of the slurry wall would have to reduce the life cycle cost of the treatment to be justified.
101	EPA		27	Regarding the recommendation of relocation of the tailings the USACE should consider evaluating additional potential hazards from moving the tailings pile besides the CO_2 emissions and fatalities. Are there other practical risks from moving the pile?	Concur	**Other potential risks include increased radon emissions and potential for dust releases, though engineering controls may mitigate these risks.**
102	NRC	General		In general, the draft report appears not to provide a strong basis for decision-making because of limitations in the analysis and because it does not compare current remediation strategies to those that are recommended. As a result it lacks the information necessary to show how the revised strategy will be more efficient and/or effective at achieving site closure goals.	Noted	See Response to Comment 103 below.
103	NRC	General	various	Technical conclusions made in the report are routinely qualified with "may be", "it appears", or "likely" which detracts from the usefulness of the document because it introduces uncertainty about the effectiveness of the proposed remedies due to a lack of data, or a lack of time to fully assess the hydrologic system. Pursuing changes to the current remedial strategy with this level of uncertainty seems unwarranted. Specific comments supporting this conclusion are provided below.	Noted	Regarding this and the previous comment, in any analysis such as this, with limited budget and time, there is always the potential that other unknown or unrecognized factors may affect the validity of the recommendations. We offer our recommendations, albeit with hedges, in the spirit of improving the project and spurring further consideration by those on the project team that know the site and its history the best.

104	NRC	2.1.2	6	Section 2.1.2 identifies the location of the former mill buildings as a potential source of contamination to the ground water. However, there is very little basis provided for such a conclusion. This section states there is "**some suggestion**" in ground water monitoring data for this conclusion. It goes on to say that the elevated uranium levels in the 1 series wells have been observed but that the "**nature of the source is unclear**."	Non-concur	The uranium concentrations in monitoring wells near the former mill location appear to be elevated relative to the surrounding area. While such a correlation would strongly suggest a causal relationship between the contamination and past mill operations, sampling data is somewhat sparse in the area and other causes such as migration from the tailings pile can not be ruled out. If a continuing source of contamination were to exist at this location, it would affect the time frame of achieving site ground water goals and should be addressed.
105	NRC	3.1	8	Section 3.1 states, "Capture is not apparent for the irrigation pumping in the downgradient portions of the uranium and selenium plumes, nor is it clear from available data that capture of the plume along Highway 605 east of the site is maintained." Based on this statement, the reviewers should not draw any conclusion about the adequacy of plume capture.	Non-concur	The statements made in the report are appropriate given the available data.
106	NRC	3.4	15	The report states, "The primary concern with the modeling conducted for the site is the simulation of the seepage of contaminated water from the large tailings pile. **From the available information** on this step in the modeling process, **it appears** the modeling did not account for the **likely heterogeneity** and preferred pathways for water injected into the tailings. **It seems likely** that the flux of water is not uniform through the pile and that large volumes of the pile still have a significant amount of their original pore fluids. **The model likely over-predicts** the performance of tailings flushing."	Concur	**The report does state this. We will strengthen the statements.**
107	NRC	4.1	17	"..heterogeneity of the materials **has likely** prevented.." "..**makes it difficult** to assess.." "**It is not obvious** the flushing program would meets its goal by 2012.."	Concur	We will strengthen the statements.

108	NRC	4.4.1	23	"This would **potentially reduce** the long-term costs for the operations, **possibly significantly.**"	Non-concur	We can not say with certainty and it was beyond the scope of our effort to provide detailed cost analysis of the impact to the costs for operating the plant.
109	NRC	7.1.4	36	"The use of no-purge sampling techniques, such as Hydrasleeves and Snap samplers **may be considered to reduce** the time necessary to sample the wells." The use of no-purge sampling was not determined to be a time saving or cost savings alternative to the current sampling methodology utilized by Homestake.	Non-concur	If the well conditions are appropriate, as noted in the EPA comments, such no-purge techniques can give good results with reductions in field time. The NRC does not provide a citation for an analysis done to assess the costs or time necessary for no-purge sampling.
110	NRC	7.2.2	37	"The number and location of control monitoring stations **may not be adequate** to meet the overall objective of ensuring compliance with the public dose limit in 10 CFR 20.1301." Given that the NRC staff has previously determined that the number and location of control monitoring stations is adequate, the reviewer should provide additional justification for its statement.	Non-concur	As indicated in your Comment 114 below, the determination of an appropriate radon background and decay progeny equilibrium ratio are important and challenging to determine. The HMC July-December 2009 SAEMR indicated that the single radon background location HMC #16 result for the period was an anomaly (significantly higher than previous readings) and that they have initiated a study to confirm that location as an appropriate radon background. We encourage NRC to work with HMC to determine an accurate distribution of radon background for use in their compliance calculations.
111	NRC	4.2	19-20	The NRC staff does not agree with the statement, "…injection of relatively clean water from other aquifers into the alluvial aquifer downgradient of the site at rates that exceed extraction complicates the control of the plumes and may do more to dilute the plume rather than treat it." We believe injection is necessary because the hydraulic control cannot be maintained in the unconfined alluvial aquifer by extraction alone. The number of extraction wells and their pumping rates would have to be increased to maintain hydraulic control to an area of this size. USACE should re-evaluate the recommendations in this section.	Non-concur	We stand by our evaluation.

112	NRC	7.1.5	36	Optimization tools mentioned in this section should have been used for this evaluation for a limited data set, at minimum, to provide a basis for recommended changes to the groundwater and air monitoring programs.	Non-concur	The application of these tools to a subset of the site would not be within scope or all that helpful - the monitoring program should be assessed holistically. The tools have been well documented at other sites and we believe would be beneficial to the Homestake site. For more information, refer to the EPA/USACE document cited in the report or visit http://www.frtr.gov/optimization/monitoring.htm.
113	NRC	7.2.2	37	Section 7.2.2, refers to the "large area potentially impacted by the Homestake effluent releases". The report should specify what area is impacted by the Homestake tailing piles radon releases. The Shearer and Sill surveys (Health Physics, 17 (1), pp. 77-88) of radon-222 concentrations in the vicinity of uranium mill tailing piles, appear to conclude that no statistically significant difference between measured radon-222 concentrations around tailing piles and background radon-222 levels could be discerned beyond a mile from the tailing piles.	Concur, in part	The paragraph in the **report will be modified** to clearly separate out the effluent releases into particulate and radon and a reference to historical radon studies will be included. See also, Comment 110 above.
114	NRC	7.2.2	37	The methods in US NRC Regulatory Guide 8.30 for radon-222 daughter measurements are better suited for assessment of worker's exposure to radon daughters indoors, and most of these methods may not be appropriate for determining either outdoor radon progeny levels or an equilibrium factor. The determination of a radon background level and an appropriate radon & radon progeny equilibrium factor are especially important and challenging to determine.	Concur	Agree with the commenter regarding the importance of determining appropriate radon background levels and radon/radon progeny equilibrium factor. Agree that the NRC methods referenced in the draft report may not adequately capture the diurnal, seasonal, and other atmospheric variations in outdoor radon progeny concentrations and **the report will be revised** to recommend that NRC work with its licensee to ensure that appropriate methods are identified and used to confirm the progeny equilibrium factor currently assumed by HMC.

115	NRC	8.0	40	Although efforts were made to take a conservative approach to modeling this site, RESRAD was not designed to be used to evaluate doses from contaminated irrigation water. There are other computer codes (e.g., GENII) that can be used to evaluate doses associated with irrigation. Other options, such as the Radium Benchmark Dose, which is discussed in 40 CFR 192 and 10 CFR 40, Appendix A, Criterion 6(6) could also be used.	Noted	The RESRAD model, though not specifically designed to address irrigation with contaminated water, was used as described in Section 8.1.1 to estimate the dose and risk from water dependent ingestion and radon inhalation pathways. The EPA is currently planning for and gathering additional data to support a more detailed human health risk assessment.
116	NRC	8.0	40	Some RESRAD parameter values may impact the dose received by the future resident such as the use of 400 acres (1.6E+6 m2) of soil irrigated with contaminated irrigation water. It is unlikely that a single individual would be exposed to the entire area while living on the site. Consideration of soil dilution associated with the construction of a house with a basement can further decrease the amount of contaminated soil a future resident may be exposed while the increase in time spent outside from 25% to 50% of the future resident's time may increase the dose. When evaluating the dose to a future resident it is also important to include all relevant exposure pathways (e.g., external exposure, inhalation, ingestion, and radon) associated with the site.	Concur, in part	The **RESRAD inputs will be reevaluated** in response to this and other stakeholder comments. Specifically, the area of contamination will be reduced to the RESRAD default of 10,000 square meters. For this conservative assessment, dilution of soil from basement construction is not considered and the receptor is modeled to be present at the site 100% of the time split evenly between indoor and outdoor activities. As shown in Tables 5 and 6 of the draft report, all relevant pathways were included in the assessment.
117	NRC	8.2.1	42	There is no basis for applying the New Mexico water quality standards for irrigation water. Removal of contaminants prior to irrigation would defeat the purpose of this remediation strategy. In addition, this section implies that the current practice of directly applying untreated extracted groundwater for irrigation is done with effluent concentrations above discharge standards. Groundwater used for irrigation has been below the discharge standards required by Homestake's license, which is based on 10 CFR 20, Appendix B, Table 2 values.	Concur	The application of specific standards is the responsibility of the regulatory agencies. See, NMED Comment 73 above. As stated in the report, the treatment alternative was developed in response to stakeholder concerns and to provide regulatory agencies treatment information, regardless of the driving reason.

118	NRC	8.2.2	43	Section 8.2.2 indicates that uranium leaching into groundwater is not considered to be a likely risk. If the risk is small, and Homestake is meeting its regulatory requirements, how will the suggestions offered to reduce uranium mobility in the irrigated soil make the current decommissioning strategy more efficient and/or effective at achieving site closure goals?	Noted	The intent of the analysis of treatment options for the irrigation water was to assess what would be required in order to address stakeholder concerns and EPA's preference for treatment.
119	NRC	9.1	44	Bullet number 1 of Section 9.1 states that ground water remediation is very unlikely to be achieved by 2017. The basis for this statement is unclear since the RSE addendum did not determine an estimated remediation date for the current remediation strategy nor did it provide an estimated remediation date for the implementation of the recommended changes.	Non-concur	Our basis is provided in section 4.1.
120	BVDA (M. Head)			Stop flushing the Large Tailings Pile.	Noted	The report recommends this.
121	BVDA (M. Head)			The injection and collection system is extracting a very very small part of the total contaminants. From 1977 to 1990 data shows there was no extraction of contaminants. The water collected was returned to the Large Tailings Pile. Since 1990 to 2010, approximately 210 gpm of contaminated water is being collected and stored apparently into one of the three evaporation ponds. The contaminants are being diluted not extracted. If Homestake/BG is allowed to drill the 39 new wells, they will be pumping 3,642 gpm while only 210 gpm is being treated, then only .0577% of water pumped out of the ground is being treated by extraction. This current method of remediation of H/BG site and surrounding area will cause a 4,500 to 8,000 acres tailings pile to the created.	Noted	
122	BVDA (M. Head)			There must be monitor wells drilled below the original mill site and water tested.	Noted	There are a number of alluvial wells located in this area already. Assessment of historical operations would help identify where releases may have occurred that would represent a significant source.

123	BVDA (M. Head)			Middle Chinle - Based on data from February 2, 1960 to May 1978, of 73 monitoring points, 32 have tds data. The average tds was 1149. (See Milton Head Exhibit I attached).	Noted	
124	BVDA (M. Head)			Use USGS resistivity flights to identify all aquifers. (See Milton Head Exhibit II attached).	Noted	
125	BVDA (M. Head)			There is data on San Andres wells. History of San Andres shows many San Andres wells are showing increase in tds and uranium. (See Milton Head Exhibit III attached).	Concur, in part	The data for the HMC deep wells do not show an increase, but in examining the U data for well 0943 and 0951, there may be some evidence for an increase, but the cause is not known. Well 0951 is not likely to be impacted by the site as it is far upgradient.
126	BVDA (M. Head)			There is data available concerning upgradient water. There was testing done as early as 1962.(See Milton Head Exhibit IV attached).	Concur	The information provided by Mr. Head indicates that near what is now the northwest corner of the large tailings pile, sulfate was measured as under 700 mg/L, but is now more than double that, as shown in the 2008 Annual Report. **This will be mentioned.**
127	BVDA (M. Head)			Construct EP3 and put anything left over from RO extraction into EP3. The addition of EP3 should eliminate the need for spraying contaminants into the air and spreading them around the area.	Noted	One of the calculations in the RSE assumes discontinuing all evaporative spraying and calculates the surface area of new pond necessary to achieve this. No further changes were made to the changes of the document
128	BVDA (M. Head)			There should be no expansion of small tailings pond near the existing STP. Put EP3 into operation. A slurry wall can be used to isolate the LTP and STP. The technology is available. There would have to be a study to include concept, engineering, feasibility and cost. This does not preclude the need to move the LTP and STP. These piles can be moved through a slurry pipe, dried down and placed in a shale or clay geological formation with no risk to community or public. Moving the tailings piles is no more of a threat to the public health than any operating uranium mill tailings. The only hindrance is the decision to move them and the money needed. However, slurrying the pile to safe permanent storage minimizes the potential for pollution as a result of the move and risk to workers.	Concur, in part	**The report will be modified to remove the suggestion to expand the pond on the small tailings pile and will acknowledge the approval of EP3.** The report discusses the use of a slurry wall, including the cost, advantages and limitations. **An analysis of the potential to move the tailings via slurry pipeline will be added.** Note that there are potential impacts of opening the tailings pile for transport, including increased radon release and contaminated dust. Slurry transport will mean the export of water from the vicinity of the site to the repository site, even if most of the water is returned via separate pipeline. This means less water in the alluvial aquifer near the site.

129	BVDA (M. Head)			Develop a comprehensive, regular and objectives-based monitoring program.	Noted	
130	BVDA (M. Head)			Allow irrigation rather than injection wells. This will allow observation of the success of extraction methods.	Non-concur, in part	We are not sure if the comment supports the use of irrigation with treated water or just the use of irrigation with untreated water. We do support the reduction in the use of injection wells.
131	BVDA (M. Head)			H/BG quotes large number of pounds of uranium and other constituents being removed from the ground waters - locate and identify these constituents. There should be a regular semi-annual analysis of the water and solids in the existing evaporative ponds.	Non-concur	There is sampling of the brine in the ponds, from what we understand, but the sampling of the solids raises many issues, including the potential to harm the liner during sampling, the variability of concentrations in the solids laterally and vertically. The measurement of the influent and effluent concentrations actually is the best way to determine the mass that is going/has gone into the ponds.
132	BVDA (M. Head)			Well X- dilution is not clean up so quit playing games with Well X.	Noted	**The text will note the impact from injection on concentrations in Well X.**
133	BVDA (M. Head)			Leaving uranium in an unlined tailings pile with as much water as the LTP has means it will continue to seep into our water forever even with a cover.	Non-concur	Though the impacts are likely to extend over a long period of time, it would not be forever.
134	BVDA TASC - GW (SRIC)	2		The DRSE Report should be revised to present a higher estimate of uranium remaining in the tailings following mill operations. The estimate of uranium in the tailings piles should be revised upward by at least 100 percent, to the 4.8 – 6.6 million pound range, based on available technical literature reports addressing uranium remaining in tailings from the HMC site mills.	Non-concur	The analysis presented in the report adequately makes the point that a substantial quantity of contaminant mass remains in the pile. The basis for the mass estimate is presented in the report. We understand there are other estimates of the mass in place.
135	BVDA TASC - GW (SRIC)	2		To the extent that one of the goals of the HMC remediation system is recovery or stabilization of the mass of uranium in the tailings, it seems to be extremely important to establish a conservative estimate of the baseline of uranium in the tailings based on site-specific data. Such an estimate is likely to be at least twice the estimate of uranium remaining in the tailings in the DRSE Report.	Non-concur	See response above.

136	BVDA TASC - GW (SRIC)	2		Though not a concern identified at the beginning of the RSE process, the DRSE Report should be revised to address HMC's technical approach, which emphasizes removal of uranium in solution in the tailings and considers the uranium not in solution to be relatively immobile and not likely to leak out of the tailings.	Concur	**This will be mentioned in section 2.**
137	BVDA TASC - GW (SRIC)	2		The DRSE Report should be revised to address, or comment generally on, the likely distribution of uranium remaining in the tailings between portion of uranium that may be dissolved in liquids in the large tailings pile and the remaining uranium not dissolved in liquids. The DRSE Report should also be revised to evaluate the effectiveness of the HMC remediation system to recover either or both portions of uranium remaining in tailings.	Noted	See response to the above comment. The report does already note the fact that much mass remains (and will remain) in the pile following the cessation of injection.
138	BVDA TASC - GW (SRIC)	3		The graphics in the DRSE Report should be enhanced to identify key locations such as wells and pond sites, identify key geological and land use features, and provide more readable graphs of contaminant concentrations over time so that vertical scales are similar, rather than a selection among arithmetic and logarithmic scales, and check that the dates for data reported are readable.	Concur	**Graphs will be improved, and the site figures will be made available as 11x17 inch size to improve readability.**
139	BVDA TASC - GW (SRIC)	3		The DRSE Report should be supplemented to identify methods or techniques to identify and address a potential flow path in the area of those wells west and north of the large tailings pile.	Non-concur	The report raises the question and we defer to the agencies and stakeholders, including Homestake, to determine if additional investigation is necessary and by whom. The upgradient location of well DD suggests another cause other than the tailings pile.

140	BVDA TASC - GW (SRIC)	3		The DRSE Report should be supplemented to identify specific additional investigations, such as borehole installations, non-intrusive geophysical methods, ground water control systems or other measures to identify and address the flow path in the well DD and S11 area.	Non-concur	See response above.
141	BVDA TASC - GW (SRIC)	3		The DRSE Report should be supplemented to include an assessment of the effect of the consistent rising trend in uranium concentrations in well DD on the value of a well at or near the location of well DD as the single down gradient monitoring well for ground water conditions for proposed pond EP3.	Non-concur	We defer to the agencies. Though such a study may be appropriate, it is beyond the scope of this RSE effort.
142	BVDA TASC - GW (SRIC)	3		The DRSE Report should be supplemented to address the location of well DD and its associated flow path within the footprint of proposed evaporation pond 3 (neither well DD or EP3 are identified on Figure 1) and the challenges to investigation and remediation of the ground water with rising uranium content in the well DD/well S11 area north and west of the large tailings pile.	Non-concur	See response above.
143	BVDA TASC - GW (SRIC)	3		The DRSE Report should be supplemented to address the extent to which the elevated uranium in wells DD and S11 and the flow path that may be associated with them occurs under or down gradient of proposed pond EP3. Illustration of the location of wells DD and S11, the extent of fault zone on the west side of the large tailings, the extent of the alluvial aquifer and proposed location of EP3 would demonstrate the relationship of these features at the site.	Non-concur	See response above.

144	BVDA TASC - GW (SRIC)	3		The DRSE Report should be supplemented by the identification of recommendations regarding future investigations to determine variations in ground water flow rates and the pattern of contaminant concentrations in the fault zone on the west side of the large tailings pile compared to less fractured portions of the aquifer occurring in that fault zone, to define the ground water flow path in that area.	Noted	Based on the comment, the water levels in the Middle Chinle and the Alluvium, as reported in the 2008 Annual Report, were compared. The West Fault does provide the potential for enhanced permeability in the Middle Chinle (and possibly the Chinle shaly intervals). The subcrop of the Middle Chinle is exposed to contaminants in the alluvium, and there is a downward gradient at the subcrop. The West Fault does not appear to allow significant vertical communication with the Middle Chinle on the east side of the West Fault, based on the significant differences in water levels. It also seems unlikely that the fault would allow northerly transport, as the head gradient in the Middle Chinle and the alluvium would appear to be to the southwest. The faulting would not appear to explain detections northwest of the tailings pile. The faulting may enhance southwestly movement in the Middle Chinle however. No changes to the report were made.
145	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to include recognition of the extensive injection well operation within a few meters of monitoring well X and the “almost instantaneous change” in uranium and sulfate concentrations in that well in 1994 when the injection system began.	Concur	The text will note the impact from injection on concentrations in Well X.
146	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to reflect the likely effect of these long-term injections of clean water on the uranium concentrations in well X. The DRSE Report should also be revised to address the data in the “Concentration Trend” spreadsheet as a demonstration that the reduction in uranium concentrations in well X is attributable to dilution resulting from injection of clean water rather than demonstration some sort of reduction in uranium concentration due to uranium removal or control in the alluvial aquifer.	Concur	See above response.

147	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to demonstrate that monitoring well X ceased being a well capable of monitoring seepage from EP1 when injection of clean water into nearby wells began only four years after the 1990 installation of EP1.	Concur	The text will note the impact from injection on the ability of Well X to detect leakage from the ponds.
148	BVDA TASC - GW (SRIC)	3		The likely influence of injection of clean water on the data generated at monitoring well X was a point of discussion during the recent NMED hearing on HMC DP-725. While NMED's recently issued final Discharge Plan DP–725 retains monitoring well X as the sole monitoring well down gradient of the four ponds, EP-1, EP-2, and the East and East Collection Ponds, witnesses for all parties recognized that the ground water concentrations at monitoring well X are "influenced" by injection and collection wells near it, as noted below. *[Hearing citations not excerpted here.]*	Noted	
149	BVDA TASC - GW (SRIC)	3		The DRSE Report should more accurately and effectively address the effectiveness of monitoring well X. The DRSE Report should also be revised to evaluate the significance of the influence of the injection wells and other aspects of the HMC injection and collection well system on uranium concentrations detected in monitoring well X.	Concur	See above response.
150	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to include an evaluation of the adequacy of monitoring well X to demonstrate "plume capture" and detect contaminants leaking from the small tailing pile, or EP1 on top of the pile, or the other ponds and tailings pile, because of the influence of injection well water on the uranium concentration trend in monitoring well X.	Concur	See above response.

151	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to address whether monitoring well X is located in a flow path that could detect seepage from the East and West Collection Ponds, EP-2 and EP-1 independent of the injection of clean water. If no flow path from the ponds to monitoring well X can be identified, the DRSE Report should be revised to identify a measure recommended by the RSE contractors to establish a more effective monitoring well in the south side of EP1, the other ponds south of the large tailings pile and the small tailings pile.	Non-concur	Given the extensive monitoring network and sampling program, the impacts of the actions in the alluvial aquifer at the site can be reasonably evaluated. We defer to the agencies for designation of the appropriate compliance points.
152	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to recommend additional monitoring well sites at locations not compromised by clean water injection, as is the case with well X, or rising uranium trends, as is the case with monitoring well DD, be identified to more effectively monitoring the current and near-term (10 yrs+) potential leakage from the four ponds.	Non-concur	See above responses.
153	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to address the adequacy of the monitoring well and point of compliance well pattern in place at the HMC site and identify alternative monitoring well locations in recognition of the sources of dilution of uranium at well X and the rising uranium concentration trend at well DD.	Non-concur	See above response.
154	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to more fully address the implications and consequences of the over prediction of flushing performances and identify recommended actions to respond to the HMC ground water model's over prediction of flushing performance.	Non-concur	The report does address the consequences of the over prediction. Additional evaluation is beyond the scope of the study.
155	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to identify the degree to which performance of flushing has been over predicted.	Non-concur	Additional evaluation is beyond the scope of the study.

156	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to identify mechanisms for more accurate prediction of flushing performance and the consequences of more accurate assessed flushing performance including, but not limited to, the likely ground water conditions and distribution of uranium and other contaminants in the large tailings pile if flushing is more accurately predicted.	Non-concur	Additional evaluation is beyond the scope of the study.
157	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to identify the parameters in the HMC ground water model that lead to over prediction of flushing effectiveness and options for revising or recalibrating applicable models the models to provide more accurate predictions.	Concur, in part	The report currently addresses the major shortcomings of the flushing model, in that it fails to account for the heterogeneities that would prevent uniform movement of flushing fluids and would allow mass to remain that will cause rebound. Additional evaluation is beyond the scope of the study.
158	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to include additional graphic information to identify the extent of the Middle Chinle and other aquifers on site and indicate where the Middle Chinle aquifer may be either used or affected by seepage from the tailings piles on the HMC site.	Non-concur	We do not believe this to be necessary to achieve the objectives of the report.
159	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to identify activities and investigations necessary to overcome the lack of accuracy regarding the hydrology of the Middle Chinle aquifer.	Non-concur	The report raises the question and we would expect others to pursue the cause for the questionable water levels in the Middle Chinle.
160	BVDA TASC - GW (SRIC)	3		The DRSE Report should be revised to identify the significance of understanding the hydrology of the Middle Chinle aquifer to the HMC remediation system and the RSE Report.	Non-concur	Additional evaluation is beyond the scope of the study.

161	BVDA TASC - GW (SRIC)	4		The DRSE Report should be revised to provide lifecycle cost, emission or energy consumption comparisons among long-term remediation options identified in order to provide for balanced comparison of long-term costs for the range of alternatives identified in comparison to the cost, long-term potential for successful completion of remediation, and consequences of continuation of the HMC remediation system as proposed.	Concur	These analyses have been conducted and will be incorporated into the draft final report.
162	BVDA TASC - GW (SRIC)	4		The DRSE Report should be revised to provide comparisons of the effectiveness of the physical barriers – slurry walls and reactive permeable barriers – that it recommends with the tailings removal options for long-term remediation of ground water at the site to meet performance objectives established in the Uranium Mill Tailings Radiation Control Act. The Act requires completion of closure and containment without active monitoring and maintenance as the measure of tailings reclamation effectiveness.	Concur	See response above.
163	BVDA TASC - GW (SRIC)	4		The DRSE should be revised to eliminate the recommendation that, "Relocation of the tailings should not be considered further given the risks to the community and workers and the greenhouse gas emissions that would be generated during such work" unless and until a balanced comparison of the full range of life-cycle costs and benefits, including considerations of long-term remediation effectiveness of the range of remedial alternatives, is incorporated in the Remediation System Evaluation.	Non-concur	We stand by our recommendation, even with the additional analysis and the assessment of the tailing slurry transport option.

164	BVDA TASC - GW (SRIC)	4		The DRSE Report should be revised to identify and evaluate both 1) long-term monitoring and maintenance costs and 2) likelihood of long-term effectiveness of the range of alternatives identified, including continuation of the current remediation system and implementation of the alternatives identified. Alternatives include elimination of the flushing system, slurry wall, reactive permeable barriers, tailings removal and any other system with potential for long-term remediation success. Consideration of long-term remediation effectiveness and monitoring and maintenance costs should be incorporated into the RSE contractor team's sustainability review so that remediation performance as well as energy consumption and worker safety issues can be considered for all alternatives.	Non-concur, in part	The sustainability analysis of the various options considers most of the recommended changes to the pump and treat system, and the alternative technologies. Additional evaluation is beyond the scope of the study.
165	BVDA TASC - GW (SRIC)	4		As tailings removal remains the only conceptual option that allows for elimination of the source of pollution from the HMC site, the DRSE Report should be revised to retain tailings removal as the sole remediation alternative that provides for the potential to minimize or eliminate the need for active long-term monitoring and maintenance after standards are attained.	Non-concur	Moving the tailings moves the location where long-term monitoring and maintenance will be needed (to the new repository). Even if the tailings are moved, there will be monitoring (and probably some ground water control) required at the Homestake site for some period of time.
166	BVDA TASC - GW (SRIC)			The DRSE Report should be revised to identify a range of spray evaporation rate and technology options in comparison to the spray evaporation technology in use at the HMC site.	Non-concur, in part	The USACE expresses its appreciation to TASC for the detailed information supplied on the different options of evaporation technology, systems, and monitoring. It is outside the scope of the DRSE, however, for the USACE to perform the study and develop alternatives to the current spray evaporation system as recommended by TASC. It is noted that not only evaporative capacity and spread would need to be considered but also the effect of brine on any revised system. **However, the USACE will include a recommendation that the current spray evaporation be evaluated by HMC using the information supplied by TASC for any optimization improvements.**

167	BVDA TASC - GW (SRIC)			The DRSE Report should be revised to identify a range of spray evaporation rate options among the remediation system modifications it recommends and identify their implications for pond configuration, acreage and evaporation performance.	Non-concur	See above response.
168	BVDA TASC - GW (SRIC)			The DRSE Report should be revised to identify the need for, and scope of, a quantitative evaluation of spray evaporator performance and effectiveness including evaporative effect, fallback or sprayed fluids, and distribution of particulates and radionuclides including radon and radon daughters passing through the spray system.	Non-concur	See above response. Also, the report specifically recommends that the radon gas potentially released from the evaporations ponds during active spraying be assessed.
169	BVDA TASC - GW (SRIC)			The DRSE Report should be revised to identify the scope of data gathering and system monitoring considerations, including spray shut-down systems during high winds, necessary for effective performance of and effective evaluation of performance of the spray system in the "forced spray plan" required by DP-725.	Non-concur	As pointed out in the information submitted with these comments, DP-725 as amended April 12, 2010, contains a condition that requires HMC to "operate the forced spray system such that the spray remains within the confines of the ponds to the extent practicable" and to submit to NMED a plan detailing sprayer operations. Defer to NMED the review of the HMC developed plan.
170	BVDA TASC - GW (SRIC)			The DRSE Report should be revised to identify the anticipated cost and timeline for completion of remediation.	Non-concur	This is beyond the scope of the study.
171	BVDA TASC - GW (SRIC)			The DRSE Report should be revised to identify the opportunity to construct and operate a renewable energy system at the HMC site as a means to generate income to offset long-term remediation costs and to provide local employment.	Concur	This will **be added to the report**, though the analysis will be limited. Solar power appears to have good potential.
172	BVDA TASC - GW (SRIC)			The DRSE Report should be revised to identify the estimated length of time that the remediation options identified will be in place or operated and bases for estimation of the longevity of those remedial options.	Non-concur	We do not have the tools to project the time to cleanup. Ground water and contaminant transport modeling may be necessary. This is beyond the scope of the study.

173	BVDA TASC - GW (SRIC)			To provide for stakeholder review of a revised DRSE Report before it is finalized, it is strongly recommended that EPA establish a timeline for distribution and RSE stakeholder review of a revised DRSE Report which includes the conclusions and recommendations resulting from the revised evaporation rate calculations and the "sustainability review" for remediation alternatives.	Concur	This has been done.
174	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — (HMC compile, summarize and report all fenceline radiological air monitoring data from the 1980s and 1990s. These data are expected to be stored in hard copies in the NRC's public document repository.	Non-concur	This request is outside the scope of the report.
175	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — Any new air monitoring stations be sited consistent with locations of monitors that had average annual radon concentrations of less than 0.7 pCi/l-air, which is the upper range of average levels reported in previous studies.	Concur, in part	The report currently recommends that HMC consider additional background monitors at appropriate locations. The use of historical survey information provides a basis for determining what those appropriate locations may be. See also Response to Comment 110.
176	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — The planned EPA Region 6 risk assessment include outdoor and indoor radon monitoring, soil surveys for gamma radiation and uranium and radium concentrations, surveys of structures to detect the use of contaminated materials, and an inventory of natural and human-made sources of radioactive materials. Monitoring of radon at HMC's fenceline monitoring stations should be done concurrently with air monitoring in the residential areas.	Non-concur	Defer to EPA Region 6. The RSE team provided some input into the scope of the EPA risk assessment, however, the EPA assessment is part of a larger regional effort.
177	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — EPA-6 consider hiring a community member to serve as a liaison between the community and EPA and its contractors during field studies associated with the assessment and at the time results of the risk assessment are presented to the community.	Noted	Defer to EPA Region 6.

178	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — EPA Region 6 review and reconsider the findings, conclusions and recommendations of the 1989 Record of Decision of the Radon Operable Unit in light of the findings of new environmental monitoring conducted as part of the planned risk assessment and by HMC under its routine and expanded monitoring program.	Noted	Defer to EPA Region 6.
179	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — HMC comply with NRC Regulatory Guide 4.14 and immediately begin monitoring Pb-210 in particulates measured at its eight air monitoring stations.	Concur, in part	The report identifies this discrepancy from the NRC guidance and recommends that the basis for not including Pb-210 be discussed in the SAEMR.
180	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — HMC establish at least one air monitoring station in the residential area southwest of the site, including consultation with BVDA, EPA and NRC before selecting a suitable residential monitoring location. Consideration should be given to establishing more than one air monitoring station in the residential area to provide an appropriate geographic distribution that takes into account local wind speeds and directions, and possible contributions to radiation releases from HMC's two irrigation plots located west of Valle Verde Estates.	Concur, in part	The report currently recommends that 2 to 3 additional radon monitors be located between the current monitoring stations near the residential areas. Given the magnitude of the calculated doses from particulate radiation sampling at the site boundary locations, HMC #4 and #5, there does not appear to be significant need to require HMC to place full air monitoring stations at greater distances from the site.
181	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — HMC compile and report all previous meteorological data, and commit to including all future meteorological data in its Semi-annual Environmental Monitoring Reports. The DRSE Report should further recommend that HMC undertake a study of localized wind patterns to determine if the tailings piles or other land features contribute to a channeling of currents into the adjacent community.	Concur, in part	The report currently recommends that wind direction data from the on-site meteorological station be collected during each monitoring period and presented in the SAEMR. HMC included a wind rose for the period of September 2008 to August 2009 in the 2009 Annual Irrigation Evaluation report. The **report will be revised** to clearly recommend that the wind rose data be included with the air sampling results in the SAEMR.

182	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — HMC establish a meteorological station in the residential area. The residential air monitoring station recommended in Section 5.1(vii) above could be co-located at a new residential meteorological station. The residential meteorological station should be capable of measuring wind speeds and directions and ambient temperature and pressure.	Non-concur	The location of the current meteorological station near the source of the contaminants on the southern side of the LTP should be adequate.
183	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — Homestake conduct and submit to NMED, NRC and EPA radiochemical analyses of precipitates deposited by the sprayers on the berms of the evaporation ponds as soon as possible.	Non-concur	The EP area is part an active remediation system on a licensed site. Upon completion of remedial action, all surface soils not covered under the final radon barrier will be required to meet the cleanup criteria identified in 10 CFR 40, Appendix A, Criterion 6(6).
184	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — Data on particulates detected at the seven perimeter air monitors be analyzed to determine if radionuclide levels are correlated with wind patterns (velocities and directions) and/or spraying events.	Non-concur	The weekly air sample filters are composited and analyzed on a quarterly basis. This integration averages out the numerous spraying events and variations in wind direction making correlation impractical. It is more appropriate to use the historical wind patterns as the basis for locating the air monitors.
185	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — DP-725 and SUA-1471 be amended to prohibit spraying when weather conditions would cause mists and precipitates to be deposited outside of the perimeters of the ponds.	Non-concur	As pointed out in the information submitted with these comments, DP-725 as amended April 12, 2010, contains a condition that requires HMC to "operate the forced spray system such that the spray remains within the confines of the ponds to the extent practicable" and to submit to NMED a plan detailing sprayer operations. Defer to NMED the review of the HMC developed plan.
186	BVDA TASC - Air (SRIC)			The DRSE Report should be revised to recommend that — An assessment be conducted on whether existing monitoring data are adequate to determine if effluent spraying is protective of public health. If the RSE Team finds that existing monitoring data are not adequate to determine if effluent spraying is protective of pubic health, the final report should identify the scope of a data-gathering program needed to make such a determination.	Concur, in part	The report already recommends that the potential for radon to be released during active spraying be assessed and recommends additional radon monitoring in the direction of preferential radon flow. The results of that assessment are deferred to the agencies.

187	BVDA TASC - Air (SRIC)			The DRSE Report should recommend that HMC reassess all input parameters to the calculation of the Total Effective Dose Equivalent (TEDE), including and especially the occupancy factor and the radon-radon daughter equilibrium factor.	Concur, in part	The report specifically recommends that HMC confirm the assumption of the radon/radon progeny equilibrium factor. The report also cites NRC guidance regarding the appropriate use of occupancy factors. **The report will specifically recommend** that the assumptions for the occupancy factor be confirmed.
188	BVDA TASC - Air (SRIC)			The DRSE Report should further recommend that the NRC staff review all assumptions and rationales presented by HMC in the annual TEDE calculation provided in the semi-annual environmental monitoring reports.	Concur, in part	The report recommends revisions to the HMC air monitoring program and the confirmation of assumptions used in the TEDE calculations submitted to demonstrate compliance with NRC requirements. See Responses to Comments 110 & 114 that encourages NRC staff to work with HMC.
189	BVDA TASC - Air (SRIC)			The DRSE Report should review the public health risks associated with chronic exposure to levels of radon observed in the community. The planned EPA risk assessment should include a summary of historic and current radon levels around the HMC site and in the community, and calculate doses and respiratory risks using those data. All management alternatives to mitigate or eliminate exposures from anthropogenic sources of radiation, heavy metals and other contaminants should be fully and fairly considered.	Non-concur	Outside of the scope of the focused review. Defer to the EPA human health risk assessment.
190	BVDA TASC - Air (SRIC)			The DRSE Report should recommend that HMC, EPA, NRC and NMED identify funding for health studies in the communities, and work with BVDA to identify uninvolved third-party organizations with appropriate credentials to design and implement health studies in the affected community. The RSE Advisory Committee, which includes BVDA members, may be an appropriate vehicle in which to begin these discussions to ensure that all stakeholders have a part in identifying funding sources and recommending health study providers.	Non-concur	Defer to the agencies.

191	BVDA TASC - Addenda (SRIC)	General		When read in tandem, the two addenda and the DRSE Report identify many unresolved issues regarding both the effectiveness of the current ground water remediation program and the long-term management of a fully remediated site. To resolve the difficult issues related to current performance and long-term management, the RSE Team should identify the full range of options in both areas and the range of additional actions and investigations to define an optimized path forward for remediation at the HMC site. By treating these portions of the remediation system optimization separately, the tailings relocation option (or options, given there are several options that have not been considered by the RSE Team, as outlined below) is dismissed prematurely prior to demonstration of an effective ground water remediation system and without the level of scientific evaluation merited by the complex and challenging conditions and the 50-year history of ground water contamination at the HMC site.	Non-concur	The analyses that have been performed are consistent with or even beyond what is typically done for an RSE. These analyses are consistent with the scope of work for the study. We disagree that the relocation of the tailings was "dismissed prematurely"
192	BVDA TASC - Addenda (SRIC)	General		To provide for more thorough consideration of remediation and long-term management options at the HMC site, the RSE Team should evaluate whether the existing EPA -Nuclear Regulatory Commission (NRC) Memorandum of Understanding (MOU) provides an effective mechanism for implementing remediation optimization. This MOU apparently supplanted the need for a Remedial Investigation/Feasibility Study (RI/FS) under authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for the “ground-water operable unit” in the mid-1980s. Absent an RI/FS, the MOU mechanism should be reviewed to ensure that all feasible options for improving and expediting ground water remediation in the short term and long-term site management and rehabilitation are considered.	Non-concur	This is beyond the scope of the study.

193	BVDA TASC - Addenda (SRIC)	General		When considered together, the contents of the addenda and the DRSE report would have major implications for the scope and form of the HMC site's remediation system if they were considered at the level of detail appropriate for review of alternatives for the "Corrective Action Plan" (CAP) under review by the NRC since 2006. If the DRSE Report was considered as a set of substantive comments on the proposed CAP license amendment currently under review by the NRC, or on the DP-200 application currently under review by the New Mexico Environment Department (NMED), implications of its suggestions and recommendations regarding regulatory actions affecting the site could be thoroughly considered.	Noted	We defer to the agencies.

194	BVDA TASC - Addenda (SRIC)	General		Since the remediation system evaluation or optimization process under CERCLA is a science-based initiative based on sound technical approaches, and not a regulatory-based process, serious consideration of alternatives for the long-term remediation of the site and the area's ground water must be completed in the context of the existing NRC license, NMED's ground water discharge permit, or both concurrently. For these reasons, the RSE Team should specify in the final RSE Report that the identified optimization opportunities should be subject to a full-scale analysis as corrective action options, including consideration of all options for tailings removal and relocation. In addition, the RSE Team should specify that this analysis should be conducted under authority of the Atomic Energy Act and the National Environmental Policy Act at the federal level and the New Mexico Water Quality Act at the state level. It is suggested that the optimization enhancements identified by the RSE Team be considered as modifications to the Homestake CAP currently being reviewed by the NRC as a license amendment. If this is done, the RSE Report could provide a basis for a "new, hard look" as it provides substantial new information not available during the review of previous license amendments.	Non-concur	The determination of the nature, scope, and timing of any future analysis of alternatives would be conducted by the agencies.
195	BVDA TASC - Addenda (SRIC)	Evap.		The RSE Team should suggest a detailed review of the full range of long-term management options, including both on-site containment and off-site disposal, in the context of remediation system optimization.	Noted	See comment above.
196	BVDA TASC - Addenda (SRIC)	Evap.		Conducting a pilot test, if needed, before incorporation of the two identified treatment system enhancements, as proposed by the RSE Team, should be incorporated into existing performance requirements for the NRC license and the DP-200 NMED ground water discharge permit to supplement and/or optimize the site's Corrective Action Plan.	Noted	We defer to the agencies.

197	BVDA TASC - Addenda (SRIC)	Evap.		The “Combination of Evaporation Capacity” analysis does include significantly expanding the capacity of the RO treatment system as a remediation system optimization option. The RSE Team should assess whether the RO plant capacity could be raised to take full advantage of all evaporation pond capacity on site. If the evaporations ponds can evaporate additional flow, the RSE team should evaluate combinations that include expanded RO treatment capacity. Expanded RO treatment capacity could allow for increased extraction of fluids containing contaminants of concern, particularly if the current system is revised to reduce the treatment burden associated with flushing flows derived from both injection and extraction.	Concur	The report does recommend measures to increase the plant throughput up to 600 gpm with allowances for maintenance. Analysis of the options of increased treatment and evaporation pond configurations will be added to the report.
198	BVDA TASC - Addenda (SRIC)	Evap.		The discussion of evaporative capacity and treatment options should include a discussion of the disposition of contaminants of concern that are managed by those systems, since they are the focus of the remediation effort. The RSE Team should suggest that the remediation system include identification of the distribution of radionuclides, metals and gross constituents in fluids and sludges that are stored in the four existing ponds and in precipitates deposited on and around the berms of the ponds.	Non-concur	There is sampling of the brine in the ponds, from what we understand, but the sampling of the solids raises many issues, including the potential to harm the liner during sampling, and the variability of concentrations in the solids laterally and vertically in the ponds. The variability would likely make characterization of the contents difficult. The measurement of the influent and effluent concentrations actually is the best way to determine the composition of materials that is going/has gone into the ponds.
199	BVDA TASC - Addenda (SRIC)	Evap.		Since Homestake has stated previously that 98.6 percent of radon emitted from the facility is from the LTP and Small Tailings Pile (STP), covering the top of the LTP with a final radon cover could substantially reduce radon emissions and resulting radiation exposures to local residents. The final RSE should suggest that once flushing is terminated, Homestake proceed expeditiously to cover the top of the LTP. (Installing the final radon cap would not preclude relocating the tailings if that option is implemented as discussed below.)	Non-concur	The regulations, 10 CFR 40, Appendix A, Criterion 6(3) and the HMC license requires that the radon flux from the piles not exceed the final radon flux standard of 20 pCi/m^{2}s during phased emplacement of the final radon cover. The HMC license (Condition 37.F.) also requires that the final radon barrier not be placed until it is demonstrated that 90% of the expected settlement of the pile has occurred.

200	BVDA TASC - Addenda (SRIC)	Carbon		The Carbon Footprint Addendum dismisses the tailings removal option based only on costs and carbon emissions, with no consideration of the long-term environmental performance goals for the site. This narrow “energy cost only” view fails to consider long-term objectives for the HMC site — ground water remediation and reduction of potential health risks for nearby residents. The addendum appears to provide only a comparison of energy budgets for three environmental management options at the site, one of which is continuing the current remediation system, with all of its previously identified shortcomings.	Non-concur	Even with tailings (and some underlying soil) removal, some ground water control would likely be necessary for some time due to contamination that has been released into the saturated site soils. Certainly, there would be some decrease in risks to the nearby residents. We do not dispute that, but note that there is some risk of exposure being transferred to another location.
201	BVDA TASC - Addenda (SRIC)	Carbon		The Carbon Footprint Addendum should be incorporated into a section of the final RSE Report related to long-term environmental management. The RSE Team should encourage retention and refinement of the tailings relocation option for analysis beyond its brief and incomplete consideration in the addendum.	Concur, in part	The carbon footprint addendum will be incorporated into the report.
202	BVDA TASC - Addenda (SRIC)	Carbon		In the Carbon Footprint Addendum, the RSE Team offers a comparison of alternatives that are not evaluated using comparable types of information. The alternatives are: (1) the current system; (2) tailings and subsoil excavation and off-site disposal; and (3) slurry wall construction. The addendum attempts to compare and contrast information drawn from the fully engineered and permitted tailings relocation program for the Moab, Utah, tailings with few site-specific considerations and the sparsest of conceptual models for the “current system” and “slurry wall” remediation options.	Noted	The analyses that have been performed are consistent with or even beyond what is typically done for an RSE. These analyses are consistent with the scope of work for the study.

203	BVDA TASC - Addenda (SRIC)	Carbon		The “current system” as conceptualized by the RSE Team would appear to be different from the “current system including flushing,” which the RSE Team projects will not meet the goal of attaining NRC-approved “action levels” for uranium and other contaminants in the alluvial aquifer by 2017. It should also be noted that the “current system” includes the use of spraying to enhance evaporation rates, a practice to which the local community has repeatedly objected, based not only on potential spray impacts on air and land quality and radiation exposures, but also on their repeated observations of sprays and spray particulates drifting into the adjacent communities.	Noted	The pump and treat system assessed in the analysis is essentially the current system for purposes of assessing sustainability. The analysis does include pumps used for the sprayers. This is conservative if the total energy use and carbon emissions from the pump and treat alternative is being compared to the removal of tailings and other options (it would make the alternatives look better relative to the pump and treat system).
204	BVDA TASC - Addenda (SRIC)	Carbon		The conceptual model for the single “new technology” option, the slurry wall alternative, may prove valuable, but there is no performance record applicable to the HMC site or a site of analogous proportions and conditions. The RSE Team should examine the slurry wall system installed at the IMC Fertilizer, Inc., Gypsum Stack Expansion in Polk County, Florida (see: http://www.ardaman.com/award2.htm). This system, which includes 20,000 linear feet of vertical cutoff walls up to 110 feet deep, is less than 20 years old and is the only example of currently implemented slurry wall technology that could be identified online. Notably, the Carbon Footprint Addendum does not use the IMC slurry wall system or any other real world example of a slurry wall system, as a model for comparison and contrast with facilities and hydrologic conditions at the HMC site.	Concur, in part	The tool used to compute the sustainability metrics allows only some site-specific input. We agree such a slurry wall is feasible.
205	BVDA TASC - Addenda (SRIC)	Carbon		The RSE Report should suggest that EPA, HMC, NRC or NMED gather data on the full cost of perpetual pump-and-treat systems with and without slurry walls. This approach would provide for a full-scale comparison of costs and benefits with the site-specific tailings removal option before that option is eliminated.	Non-concur	We defer to the agencies to determine whether additional study of the alternatives are warranted.

206	BVDA TASC - Addenda (SRIC)	Carbon		A significant portion of the energy and safety costs associated with the tailings relocation option is associated with the transport of tailings and subsoil to an alternative site outside of the San Mateo Creek floodplain. Identification of a site, or sites, closer to the existing tailings facility and thorough consideration of transportation alternatives (e.g., a slurry pipeline with wastewater recycling, conveyor-belt systems, or rail transport) may allow costs identified for the tailings relocation scenario to be significantly reduced.	Concur	The slurry option was evaluated and will be described in the report.
207	BVDA TASC - Addenda (SRIC)	Carbon		Truck driver and equipment operator jobs are of fundamental importance to communities with a history of mining activity. Both are associated with safety risk, based on miles logged on the equipment. Employment opportunities offered by tailings removal may represent the largest number of local jobs available in the uranium industry for many years unless and until a new uranium mill is constructed to process ore from the hard rock uranium mine proposals in the Mt. Taylor area. As a point of comparison, the potential employment opportunities associated with tailings relocation should be recognized for the substantial personal, corporate and governmental income it could generate, and for its potential to add value to the local economy by removing a contaminant source from a floodplain upstream of a growing community. As it now stands in both the DRSE Report and the addenda, the relocation option is viewed only as a set of safety risks and carbon emissions, with no other attributes.	Concur	We will mention the economic impacts of such a project in the report.

208	BVDA TASC - Addenda (SRIC)	Carbon		The RSE team offers a set of important but arbitrary assumptions that are heavily weighted in favor of the unproven pump-and-treat and slurry wall remedies. Those assumptions allow for a 75-88 percent reduction in additional pump-and treat technology and operating costs for a slurry wall over a 50-75 year period, but do not indicate whether applicable standards will have been met or pre-existing ground-water quality restored through the use of these remediation methodologies. The failure to consider full-scale, long-term management costs for the "current system" and slurry wall alternatives compared with tailings relocation gives those options an unwarranted advantage that is not supported by the performance of those technologies.	Non-concur	The ground water extraction and treatment system can be effective in preventing migration and reducing the footprint of dilute plumes. We would not characterize it as "unproven."
209	BVDA TASC - Addenda (SRIC)	Carbon		The assumptions of the Carbon Footprint Addendum should be modified to extend the active life of the HMC site's proposed pump-and-treat system and slurry walls to a reasonably long period, specifically "up to 1,000 years, to the extent reasonably achievable, and, in any case, no less than 200 years," as required in 10 CFR 40, Appendix A, Criterion 6(1)(i), the long-term performance standard set out to comply with the Uranium Mill Tailings Radiation Control Act of 1978, which the U.S. Department of Energy (DOE) must apply to the HMC site if and when current site remediation standards are attained and the site is deeded to DOE.	Non-concur	The carbon footprint for the pump-and-treat system is easily scaled if a longer time frame would be considered. Note, though, that the scope of the system will probably decrease over time.

210	BVDA TASC - Addenda (SRIC)	Carbon		The current remedial system at the HMC site has not been shown to be effective enough to meet projected performance milestones identified by HMC and regulatory agencies, even after more than 30 years of active remediation conducted by a site owner with the capacity to modify pumping, active evaporation and treatment activities. No slurry wall examples are referred to by the RSE Team to support a major drop-off in slurry wall costs over a 50-75 year period, much less characterization of the effectiveness of a slurry wall to meet environmental standards.	Non-concur	Our analysis only considered the impact of slurry wall construction. There is little operation and maintenance for a slurry wall. There are a number of slurry walls that have been constructed for environmental purposes, and when properly constructed, they function well over extended periods of time. Maintenance is generally to assure there are no extreme head differences across the wall.
211	BVDA TASC - Addenda (SRIC)	Carbon		The DRSE Report attributes a long-term lack of success to the site's current remediation system, notably the flushing program that the RSE Team recommends for discontinuance, when compared with attainment of ground water remediation goals. No effort is made in the Carbon Footprint Addendum or other portions of the DRSE Report to demonstrate any longterm performance attributes of a slurry wall system.	Non-concur	See response above.

212	BVDA TASC - Addenda (SRIC)	Carbon		The lack of success in attaining remediation, including NRC-authorized "action levels," is reflected in the Concentration Trends spreadsheet posted to the RSE website by the RSE Team on March 18, 2010, and discussed, in part, in the previous TASC report, "Observations and Recommendations Regarding the Draft Focused Review of Specific Remediation Issues for the Homestake Mining Company (Grants) Superfund Site, February 2010 – Ground Water Considerations, May 6, 2010." The concentration trends compiled by the RSE Team from HMC site data show little, if any, reduction in uranium concentrations across large portions of the site, including (as identified on the tabs of the Concentration Trends Spreadsheet) the west, north and south sumps, the NW, NE, SE and SW tails, and wells S2 AND B4. Those locations are areas not affected by the dilution "plumes" associated with the injection well systems, which so heavily influence Monitoring Well X, as discussed in the May 6, 2010 comments on ground water aspects of the DRSE Report.	Concur	Additional discussions regarding some of the trend plots for the sumps and drains has been added to the report.
213	BVDA TASC - Addenda (SRIC)	Carbon		If the RSE Team recognizes the lack of demonstrated long-term success with the current remedial system and the lack of any demonstration of slurry wall performance over the long-term, then the tailings relocation option remains the only remedy that can attain clean-up standards at the site, much less attain cleanup standards without long-term active monitoring and maintenance. The tailings relocation option is the only option that offers the possibility of a final remedy for decontaminating ground water by removing the source of the pollution — the unlined tailings piles. The current system and slurry wall options are essentially treatment methods that would operate in perpetuity.	Non-concur	We do not necessarily believe the pump and treat system would have to run in perpetuity. We can not estimate the true duration.

214	BVDA TASC - Addenda (SRIC)	Carbon		Some of the long-term environmental management bonds for New Mexico facilities include replacement of pumping systems for perpetual pump-and-treat programs, such as at the Chevron-Questa molybdenum operations. Similar perpetual treatment costs can be expected if some variation on the current remedial system or the slurry wall system is eventually used instead of the tailings relocation option.	Noted	
215	BVDA TASC - Addenda (SRIC)	Carbon		Retention of the tailings relocation option will allow for cost and performance estimates for that option to be optimized and will allow for consideration of appropriately long-term (hundreds to thousands of years) costs and performance estimates for the other two environmental management scenarios, the current system and slurry walls, to be assessed at a detailed level incorporating conditions in and around the HMC site.	Non-concur	Note that the relocated tailings would also require care for hundreds of thousands of years.
216	BVDA TASC - Addenda (SRIC)	Carbon		A new site for permanent disposal of the tailings would have to meet current NRC and NMED standards, including below-grade disposal in multi-barrier trenches, placed in a geotechnically suitable location removed from human settlements (see 10 CFR 40, Appendix A, Criteria 1, 3, 5 and 6, among others). Accordingly, the tailings relocation option should remain as a primary option for long-term management of HMC site tailings, unless and until an effective remedy is demonstrated.	Noted	We defer to the agencies.
217	BVDA TASC - Addenda (SRIC)	Carbon		Funding the life-cycle cost of remediation at the HMC site has been and will continue to be a significant public cost. Accordingly, consideration should be given to use of the site for renewable energy generation to offset carbon costs and fund remediation and local employment.	Concur	A brief analysis of alternative energy options at the site has been added. We would hope that some future use of the site will include alternative energy generation, particularly solar.

218	BVDA TASC - Addenda (SRIC)	Regional GW		The two RSE Report addenda continue to emphasize short-term (50-year or less) conditions in San Mateo Creek, including the HMC site, rather than longer-term(100-year and beyond) flow conditions in which historic flows may be restored. The HMC site does not exist in isolation from the historical surface and groundwater flow patterns of the watershed around it.	Noted	We agree the site needs to be considered in a regional context. We have attempted to consider upgradient and downgradient conditions that affect the interpretation of site conditions, but a full regional analysis was beyond the scope for this study.
219	BVDA TASC - Addenda (SRIC)	Regional GW		The historic flows in San Mateo Creek, including, but not limited to, flows from proposed uranium mine dewatering projects (see the Roca Honda Mine application: http://www.emnrd.state.nm.us/MMD/MARP/permits/MK025RN.htm; click on "Mine Operations Plan") will provide a perpetual source of upstream flow, both surface and subsurface, into the HMC site without requiring an extensive, perpetually-endowed pumping effort.	Noted	See response above.
220	BVDA TASC - Addenda (SRIC)	Regional GW		The historic flows of Bluewater Creek, retained by the rapidly aging Bluewater Dam in the Zuni Mountains, are likely to return to the Bluewater Valley eventually and also provide a perpetual source of upstream flow.	Noted	This is beyond the scope of the study.
221	BVDA TASC - Addenda (SRIC)	Regional GW		Management of environmental management activities on site continues to assume that the small and large tailings piles in the floodplain of San Mateo Creek near its confluence with Bluewater Creek will continue to be permitted and maintainable as permanent disposal sites. These piles are not lined, will take many more years to dry out before they cease to be sources of fluid infiltration to the alluvium and underlying Chinle bedrock, and, in the case of the Small Tailings Pile, will be the final disposal location for solid wastes associated with the current remediation system.	Noted	This is beyond the scope of the study.

222	BVDA TASC - Addenda (SRIC)	Regional GW		Management of the thousands of acre-feet per year of water that flow through the area affected by the HMC site tailings continues to evolve. The RSE Team should consider much longer-term conditions than the 50-year life of HMC in the Bluewater Valley. The RSE Team, and applicable regulatory programs, should aim to restore natural ground water and surface water flow conditions without active maintenance as the appropriate environmental conditions if and when standards are attained in areas affected by HMC operations. Final conditions should not rely on deed restrictions and temporary provision of alternative water supplies.	Noted	This is beyond the scope of the study.
223	BVDA - Addenda (Head-Dylla)			The Large Tailings Pile restricts a major flood plain. It is unlined and will leak contaminants in perpetuity.	Noted	The severity of the leakage will vary over time.
224	BVDA - Addenda (Head-Dylla)			The Large Tailings Pile as well as the other tailings pile and waste from current evaporation ponds must be removed to a safe, permanent storage site. No other alternative provides a full remedy, protective of future generations. We hereby request the EPA to extend the USACE's scope of work to include a serious and full consideration of removal and long-term storage of the tailings piles and contamination wastes.	Noted	We defer to the agencies to determine whether additional study of the alternatives are warranted.
225	BVDA - Addenda (Head-Dylla)			If Homestake/Barrick's expert is correct and most of our radon exposure comes from the tailings piles and not the ponds, the tailings piles need interim cover to reduce radon exposure to our community until they are removed.	Noted	The report includes recommendations to increase radon monitoring locations and to confirm assumptions used in the radon flux measurements and radon dose calculations for comparison to the regulatory limits. HMC has increased the interim cover thickness on the LTP twice to address high radon flux measurements.

226	BVDA - Addenda (Head-Dylla)			Clearly, Homestake/Barrick Gold must increase RO capacity to enable a full cleanup of contaminated groundwater. The RO process must be adequate to eliminate the need for spraying, which BVDA continues to oppose because it exposes the community to radon and has never been confined to pond berms as aerial photos and community experience confirm.	Concur	The report addresses options for expansion of capacity.
227	BVDA - Addenda (Head-Dylla)			BVDA assumes and expects that the optimization identified by the RSE process will become the basis of a more complete review of Homestake/Barrick Gold's Corrective Action Plan by the NRC under the Atomic Energy Act and the National Environmental Policy Act and that the NMED will use it in future Discharge Plans under the NMWQA.	Noted	We defer to the agencies to determine whether additional study of the alternatives are warranted.
228	BVDA - Addenda (Head-Dylla)			Time is of the essence. Our community has suffered long enough and it is no longer sufficient for the NRC to simply allow another five years for cleanup. This has been the policy for too long and has allowed Homestake/Barrick Gold to evade their responsibility with inefficiency and delays. New cleanup goals are needed and Homestake/Barrick Gold must commit the resources to solve this contamination problem.	Noted	
229	BVDA - Addenda (Head-Dylla)			BVDA hopes and expects there will be further opportunity to comment on the RSE report before it is finalized and made public. BVDA looks forward to learning soon how the Nuclear Regulatory Commission and Homestake/Barrick Gold plan to implement RSE recommendations once the report is finalized.	Concur	The draft final document will be made available to all members for review.
230	NMED - Addenda	Evap.		Elements of the "proposed pumping scenario" should be briefly summarized in this appendix for additional clarity to the reader. From Section 4.1 of the RSE, NMED understands that the primary element of this scenario is discontinuation of current flushing for the Large Tailings Pile.	Concur	This will be clarified in the appendix.

231	NMED - Addenda	Evap.		The projected effluent rate of the toe/tailings drain collection system (65 gpm [Table 5]) under the proposed pumping scenario inexplicably is indicated to be higher than that of the current pumping scenario (61 gpm [Table 4]). Although the rate under the proposed pumping scenario might equal that of the current pumping scenario temporarily, the RSE states that the rate from this source should decrease significantly with time (Section 4.1, p. 19). Therefore the analysis presented in Tables 2 through 7 should be reviewed and modified accordingly to account for this projected decline.	Noted	The assumption was that the current flow would continue for some time and decline. The current flow would represent "worst case" conditions for assessing evaporation capacity.
232	NMED - Addenda	Evap.		The Corps of Engineers' RSE team should consider including an analysis of possible modified evaporation rates or influent rates under implementation of possible modifications suggested in section 5.3, and the consequent effects on the necessary evaporation capacity.	Non-concur	The decreases in evaporative loading would need to be determined through either the actual pretreatment pilot or more detailed design of the addition of a high performance column. This is beyond the scope of the RSE to perform.
233	NMED - Addenda	4.4.4		Implementation of a slurry wall, as included in Table 4, would necessitate continuation of ground water extraction in perpetuity; is unclear what time period is modeled in the calculation that is presented in Table 4.	Noted	The conditions assumed/modeled are based on recent concentrations and estimated flows.

Homestake Mining Company's Response to Recommendations Contained in the U.S. Army Corps of Engineers' Focused Review of Specific Remediation Issues:

An Addendum to the Remediation System Evaluation for the Homestake Mining Company (Grants) Superfund Site, New Mexico (Draft Report, February 2010)

May 7, 2010

Homestake Mining Company (HMC) has prepared the enclosed responses to the recommendations contained in the U.S. Army Corps of Engineers' (ACOE) evaluation of the remediation system at the Grants, New Mexico Superfund Site. Several recommendations are provided relative to the extraction and injection system, groundwater characterization, monitoring program, and water treatment. A summary of the recommendations is presented in the Executive Summary of the ACOE Draft Focused Review of Specific Remediation Issues, An Addendum to the Remediation System Evaluation (RSE) Report, and each recommendation is presented below followed by HMC's response to the recommendation. Our responses focus on the recommendations made by the ACOE and we have not attempted to address every issue. HMC has identified inconsistencies or incorrect statements in our review of the Draft RSE Report and each is discussed at the end of this document in Attachment A.

The Grants site is recognized as a complex site with multiple regulatory agency oversight. Prior reviews note that "[t]he Site is well maintained and remedial actions performed at the Site have reduced contaminant levels on-site as well as plume size reduction and containment."[1] Further, that "[t]he groundwater collection and injection system appears to contain the contaminated groundwater and has been effective in reducing groundwater contaminant concentrations within the impacted aquifers."[2]

As previously determined in the December 2008 Draft RSE Report, there is no indication that HMC's overall remediation strategy and the current regulatory agencies is deficient in protecting human health and the environment. This fact is further substantiated by the Agency for Toxic Substances and Disease Registry's Health Consultation report, which "categorized the groundwater in the private wells not connected to the Milan water supply as a no apparent public

---

[1] Second Five-Year Review Report for Homestake Mining Company Superfund Site, Cibola County, New Mexico, AVM Environmental Services, Inc. and U.S. Army Corps of Engineers, Albuquerque District, August 2006.

[2] *Id*.

health hazard."[3] Further, the December 2008 Draft RSE Report acknowledged the groundwater flow regime is understood and containment of the contaminant plume has been achieved through implementation of a hydraulic barrier downgradient of the Grants site tailings piles, and there is no contribution of contaminants from the tailings piles to offsite groundwater. The current Draft RSE Report also notes that "the current remediation systems have been making significant progress in improving groundwater quality at the site. . . ."

With this background in mind, HMC submits that the current evaluation fails in its mission to provide concrete recommendations to enhance the remediation system at the Grants site. HMC understood the purpose of this review was to suggest other approaches or technology initiatives that could be incorporated in conjunction with HMC's current remediation system to increase efficiency in achieving site closure goals at the site. The ACOE evaluation does not accomplish this purpose. HMC is actively and aggressively remediating the site with "significant progress." The ACOE evaluation offers little in the way of aggressive remediation, and in fact suggests less active approaches (*i.e.*, less flushing of the large tailings pile). The recommendations contained in the evaluation are often inconsistent and reflect a misunderstanding of the site's closure goals.

HMC's comments and suggestions to the ACOE evaluation outline some of the areas where HMC does find agreement with recommendations in the Draft RSE Report and in those cases it presents our plan for addressing those recommendations.

HMC has identified a number of areas where disagreement exists in the conclusions and recommendations; wherever possible, we have provided a rationale for our disagreement and have included salient information that supports our position or perspective on the particular issue. In a number of areas, HMC finds that a thorough technical understanding of the issue leads to a different conclusion or recommendation than what is outlined in the Draft RSE Report. As a paramount example, the recommendation that flushing of the large tailings pile should be "discontinued" or "curtailed", at a minimum, is reflective of a lack of understanding of the hydraulics and geotechnical and geochemical mechanisms that are in play within the tailings pile. As established by the geochemical modeling, the soluble portion of the uranium in the tailings pile has been or will be collected, while the insoluble portion of the uranium will remain immobile. As such, we strongly disagree with the conclusions and recommendations, particularly in light of the fact that the flushing program is advancing to the latter stages of that program activity (and is demonstrating success) as part of the overall remediation strategy at the Grants site.

Another example of significant disagreement, and there are others that are detailed in the following text of HMC's comments, is the suggestion that ion exchange is an effective

[3] Agency for Toxic Substances and Disease Registry, "Health Consultation, Homestake Mining Company Mill Site, Milan, Cibola County, New Mexico," June 26, 2009.

alternative to treat collected groundwater being applied in those areas where HMC is currently using land application/crop irrigation. HMC stresses that the need to move significant volumes of water is absolutely necessary to advance restoration efforts. The option suggested by ACOE has been evaluated, and the conclusion has been that a prohibitive degree of pre-treatment is necessary to deal with the inherent water chemistry that is evident in much of the groundwater in the area of the Grants site — irrespective of whether the groundwater has been impacted by the existence of the Grants tailings piles since the 1950s. Addressing this issue, and operation of the ion exchange system itself, carries with it the need to manage waste streams from the process. Recent experience has shown that management of remediation process waste streams in storage ponds (or expansion thereof) at the Grants site is problematic at best.

The ACOE evaluation is overreaching in reviewing areas that do not pose any risk at the site. The evaluation fails to consider the U.S Environmental Protection Agency's (EPA) prior findings that the operating HMC mill and tailings embankments "are not contributing significantly to off-site subdivision radon concentrations."[4] It is difficult to understand why ACOE is raising radon issues when the site is no longer operating, when these issues were found to pose no risk during operations and before partial cover of the tailings pile was put in place. Further, events such as the New Mexico Environment Department's approval of HMC's DP-725 discharge permit has addressed issues concerning the site's evaporation pond system emissions and are no longer at issue.

The ACOE evaluation also raises issues in areas in which HMC is operating beyond its license and permit requirements. Concerns over HMC's current level of monitoring are misplaced. Approximately 80 wells are required to be monitored under current license and permits, yet HMC voluntarily monitors a significant number of other wells to access performance of the remediation system and to continually characterize the extent of on-site and off-site impacts to groundwater. HMC's efforts are incorrectly characterized as redundant and not clearly tied to objectives. Like several areas of the ACOE evaluation, HMC fails to understand how such recommendations will enhance the remediation of the Grants site.

The Scope of Work (SOW) for the "second phase" of the RSE that was to govern the task elements of the report draft under current consideration was finalized in August 2009. This was after several months of effort and review by members of the RSE Advisory Group. HMC's observations have been that, while the SOW was followed in general terms, it was not in others. Several of these areas have been commented on in depth in the body of our comments and will not be repeated here. One of the significant objects of the evaluation was to "[e]valuate the adequacy of plume capture, horizontally and vertically, of the groundwater plumes in the alluvial and Chinle aquifers, using the recent EPA guidance. . . ." As part of that objective it was stated

[4] Record of Decision, Homestake Mining Company, Radon Operable Unit, Cibola County, New Mexico. EPA Region 6, Dallas, Texas, 1989.

that a conceptual model would be evaluated and refined and further that a “limited” assessment of the approach to groundwater modeling conducted by HMC would be performed. This objective was not accomplished. To the contrary, the entire report reflects a lack of understanding of the groundwater system, as well as the fate and transport modeling for the site. The hydrologic setting of the Grants site is admittedly complex; nevertheless, it has to be understood in order to draw any inferences or conclusions regarding opportunities, if any, to improve upon the current remedial systems that are in operation currently at the site.

Another stated objective in the SOW was to assess potential modification to the reverse osmosis (RO) units and related treatment components to achieve full capacity operations of the treatment plant. HMC does not see in the Draft RSE Report any suggested changes or additions in this area.

Another SOW objective was that there would be an attempt to “evaluate the projected evaporation rates for the new and existing ponds.” The conclusions in this area are problematic. It is understood that a correction has been made in some of the calculations for that effort since issuance of the Draft RSE Report. Because the present conclusions are not based on the best possible numbers, we will reserve our comment until that work has been completed. It should also be noted that, after three years of permitting effort, the third evaporation pond for the project has been approved and permitted by the State of New Mexico since the issuance of the Draft RSE Report. This will allow for expanded operation of the present RO treatment system, irrespective of the debate over needed or necessary storative and evaporative capacity that the Grants site may need in the future while groundwater remediation efforts advance.

HMC believes the ACOE evaluation was inconsistent and speculative in numerous instances. The evaluation’s recommendations are often contradictory to the report’s findings. Many of the issues raised in the evaluation are based on unsubstantiated stakeholder concerns. HMC believes the evaluation should be a technical document, limited to factual issues. HMC requests that ACOE seriously review HMC’s responses and comments and revise and/or remove many of the unsubstantiated and inconsistent recommendations from the final RSE report.

Recommendation No. 1 - The flushing of the tailings pile should be curtailed.

HMC Response:

The ACOE report recommends, in the Executive Summary, that flushing of the tailings pile should be curtailed; Section 9.2 recommends that the flushing of the tailings pile be discontinued. HMC disagrees with this recommendation, irrespective of the inconsistency of the two statements, and it should be removed from the final RSE report. The ACOE recommendation is based on the following points:

1) Flushing is unlikely to be fully successful at removing most of the original pore fluids.

2) Flushing is unlikely to remediate the source mass in the pile due to heterogeneity.

3) There is a potential for rebounding in contaminants concentrations following cessation of flushing.

4) The addition of water to the tailings complicates capture of water from the alluvial aquifer.

HMC has evaluated the success of the flushing program in removal of source mass. HMC's response to Recommendation No. 2 (presented later) discusses the mass removed, and Figure 5 of that response shows that the mass is being consistently removed through the flushing program. As noted by the ACOE, there is a large amount of heterogeneity in the hydraulic conductivities within the pile due to the presence of low-permeability zones, principally composed of tailings slimes. However, the flushing program works to overcome this heterogeneity and provide the driving force for the movement of soluble uranium out of these low-permeability zones. Figure 1 provides a conceptual illustration of the performance of the flushing program.

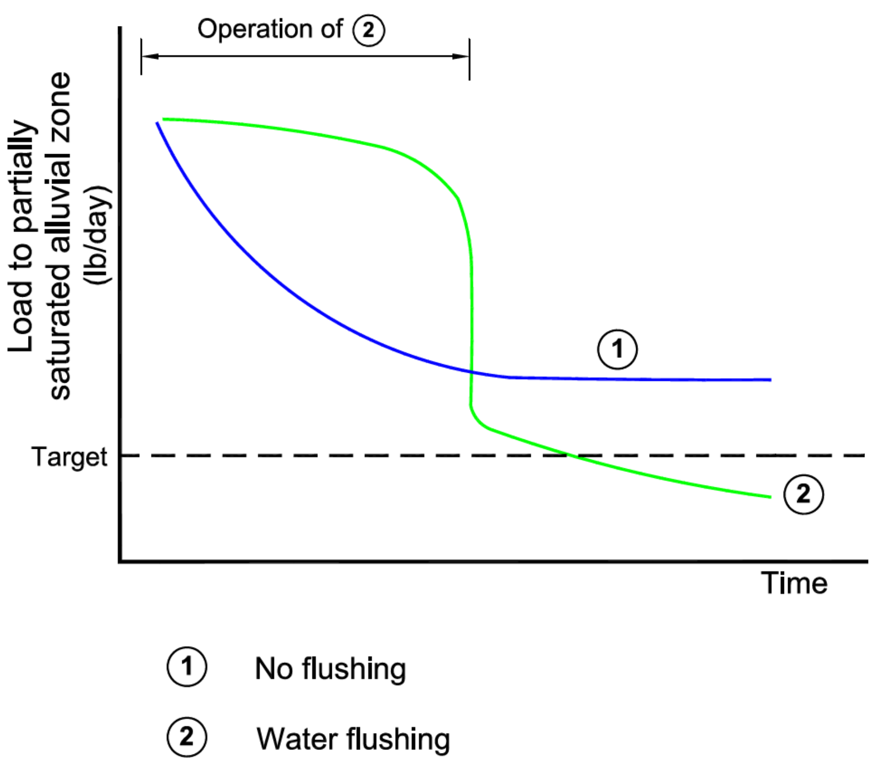


Figure 1. Conceptual performance of the large tailings pile with and without flushing.

Figure 1 depicts that, although uranium concentrations in the partially saturated alluvial zone beneath the tailings pile remain elevated for a period of time during flushing (line labeled "2" in Figure 1), the load to the partially saturated alluvial zone beneath the tailings is much more effectively controlled. Flushing provides a means to achieve concentrations well below the target corresponding to a concentration of 2 milligrams per liter (mg/L) underneath the tailings. Without flushing, uranium load drops off gradually, but concentrations remain high and, due to continual draindown of pore water with elevated concentrations of uranium, the target is never achieved (line labeled "1" in Figure 1). The Executive Summary of the ACOE report states as one of the conclusions that the seepage modeling likely overestimates the efficiency of flushing of the tailing; however, this is not the case. The model has been able to represent performance of the flushing program. There is currently a slight lag between actual and predicted performance because of the inability to flush at full capacity due to the lack of adequate evaporative capacity; however, this is not a function of model predictability and reliability. The flushing program can now proceed as planned in light of the recent approval of DP-725 and construction of Evaporation Pond 3 (EP-3).

With respect to rebound in contaminants following cessation of flushing, this is unlikely given the following factors:

1) Geochemical conditions in the tailings pore water, and the resultant chemical form of uranium, that serve to minimize the adsorption or precipitation of uranium in the tailings

2) The aggressive nature of the milling process, in terms of its efficiency at creating soluble uranium

3) The recalcitrant nature of any uranium that remains in the solid portion of the tailings

These factors are addressed here in detail.

1) The majority of the uranium in the tailings is present in the soluble form due to the presence of elevated pH and high alkalinity. This is a consequence of the milling process; the alkaline leach process was very efficient at keeping uranium in solution and is discussed below. In order to evaluate the chemical form of uranium in the tailings, HMC has performed geochemical modeling using the software Geochemist's Workbench (Rockware, Golden, CO) and the Lawrence Livermore National Laboratory thermodynamic database (Delaney and Lundeen 1989) edited to include the most recent thermodynamic constants for uranium based upon the Nuclear Energy Agency (NEA) database (NEA 2010) and work by Bernhard et al. 2001 (for the soluble calcium uranium carbonate complexes). The values provided by NEA have undergone rigorous review and consideration (by examining the experimental methods and calculations used to derive them) and were formally accepted only after they withstood critical scientific review. The

tailings pore water chemistry for well EH-11, screened within the tailings impoundment, is provided in Table 1. The results of geochemical modeling to predict uranium chemical speciation, based on the tailings pore water chemistry, are provided in Figure 2.

Table 1. Tailings Pore Water Chemistry, Well EH-11 (pH 10).

Constituent	mg/L	g/mol	mM	log M
UO_2^{2+}	12.8	238	0.05	-4.27
Ca^{2+}	3	40	0.08	-4.127
Mg^{2+}	0.9	24	0.04	-4.43
Na^{+}	3730	23	162	-0.79
K^{+}	13.9	39	0.36	-3.45
Cl^{-}	379	35	10.8	-1.97
SO_4^{2-}	3410	96	35.5	-1.45
HCO_3^{-}	1460	61	23.9	-1.62
Se^{6+}	0.072	79	0.001	-6.04
Mo^{6+}	47.5	95.9	0.50	-3.30

Note: Nitrate and vanadium were not detected in pore water.

Geochemical modeling indicates that, at the pH of the pore water (pH 10), uranium is present as the soluble calcium uranium carbonate complex ($Ca_2UO_2(CO_3)_3$) in the tailings pore water. The soluble forms of uranium are dominant in the tailings pore water due to the excess of bicarbonate relative to uranium (Table 1), and similar concentration of calcium. Under these conditions, it is highly unlikely that any solid phase uranium can persist beyond the completion of flushing and remain available for re-dissolution. Studies have shown that uranium present as uranyl carbonate or calcium uranium carbonate is very poorly sorbed by solid mineral phases (Zheng et al. 2003), and this further supports the conceptual model based on soluble uranium resident in tailings pore water. Uranium solid phases are under-saturated (prone to dissolution), and are not expected to form at the uranium concentration and pH conditions in the pore water (solid phase forms of uranium are depicted in Figure 2 as yellow areas; soluble uranium is shown as blue areas).

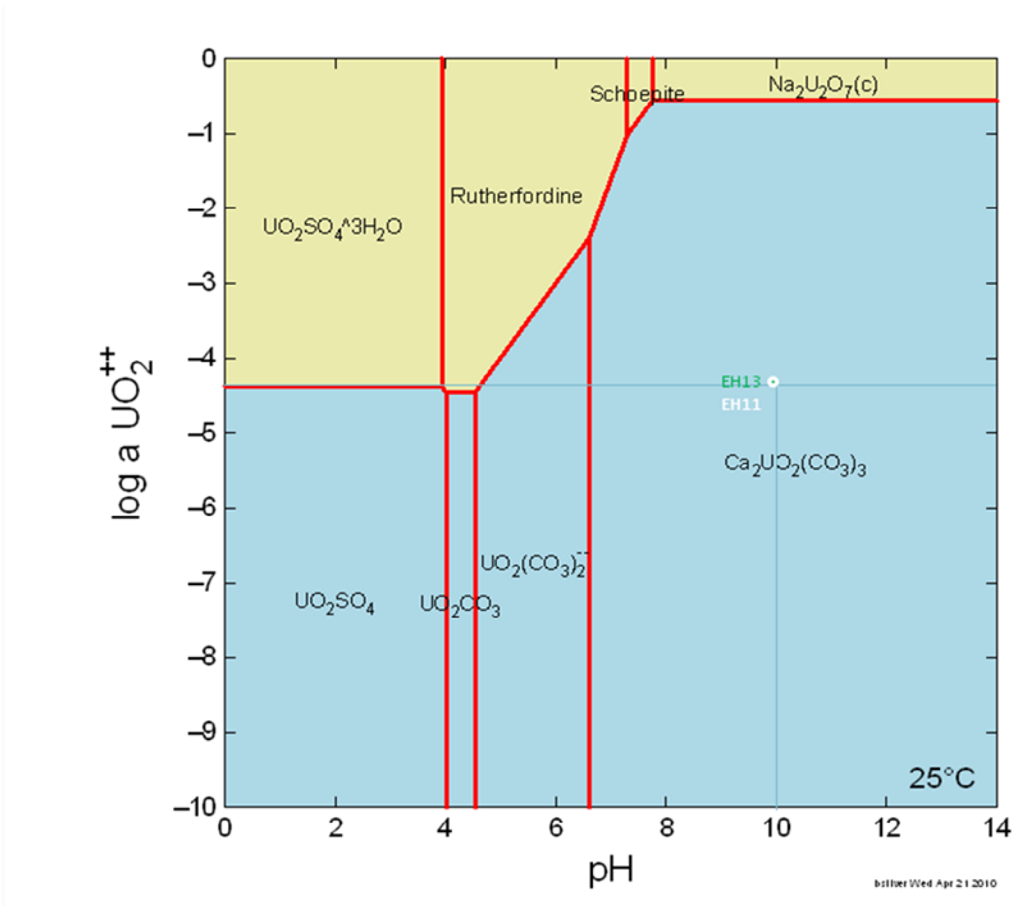


Figure 2. Results of geochemical modeling of uranium chemical speciation as a function of uranium concentration and pH. Note that the wells screened in the tailings, EH-11 and EH-13, are shown on the figure, with uranium present as the calcium uranium carbonate soluble complex in these wells. Note that the y-axis shows the log of the activity of uranium (uranium concentration).

2) A re-examination of the milling process also leads to the conclusion that very little uranium persists in solid form. The milling process was aggressive in terms of physical alteration of the ore and chemical leaching (Skiff and Turner 1981). The result of the milling process is that it dissolved the majority of uranium present in the ore that could be released under alkaline leach conditions. In addition, the uranium that remained in the solids was locked up in recalcitrant, non-leachable forms. Two basic types of ore were handled at the mill: Sandstone (80 to 85 percent of mill feed) and Limestone (15 to 20 percent of mill feed). The ore consisted of uranium minerals coffinite $[U(SiO_4)_{1-x}(OH)_{4x}]$, uraninite $[UO_2]$, tyuyamunite $[Ca(UO_2)_2(VO_4)_2 \cdot 5\text{-}8\ H_2O]$ and carnotite $[K_2(UO_2)_2(VO_4)_2 \cdot 3H_2O]$. The ore was found as an impregnation, a pore filling, or a

cementation between sand grains. The ore was crushed to an initial particle size of 2 millimeters (mm); the sandstone was ball milled so that 10 percent was greater than 0.3 mm and 35 percent was less than 0.07 mm. The limestone feed was milled twice so that 5 percent was greater than 0.2 mm and 50 percent was less than 0.07 mm. The thickened slurry was leached in two stages, with the first consisting of a pressure and temperature leach (at 60 pounds per square inch and 200° F) for 4.5 hours. The second stage consisted of an air-agitated atmospheric leach at 170° F for 12 hours for the sandstone and 24 hours for the limestone. The leached slurries were then processed through 3 filtrates stages and repulped with recycled tailings pond solution and slurried for tailings disposal. Tailings solution was recovered through decant towers and returned to the mill for soluble uranium removal (to less than 10 parts per million [ppm]).

3) The ACOE suggests that the large tailings pile contained an estimated 2.6 million pounds of uranium, present in the tailings at the end of the operation of the mill. This is based on information provided in EPA-402-R-8-005, Table 3-13; this table acknowledges that uranium present in tailings after alkaline leaching was present at a much lower concentration than from tailings after acidic leaching, and may be as low as 0.004 percent. Based upon the details provided in (1) and (2) above, the majority of the uranium deposited in the tailings pile was soluble and dissolved during the milling process but not recovered during filtration (i.e., dissolved in water that could not be recovered from the thickened slurry), and a portion present in recalcitrant mineral phases and as insoluble crystalline forms of uranium. The flushing process focuses on the soluble uranium; the insoluble forms will not be soluble in the tailings pore water under current or future geochemical conditions due to their highly insoluble nature. Any uranium present as secondary mineral precipitates (i.e., not part of the original minerals in the ore, but re-precipitated in the tailings) will also be insignificant relative to the dissolved uranium due to the conditions described in (1) above. A portion of the estimated 2.6 million pounds will, therefore, always be permanently fixed in the tailings, and flushing has removed an estimated 520,000 pounds of uranium (see Response No. 2 below) with the remaining soluble uranium, the only form of uranium of concern for groundwater, to be addressed through continuation of the flushing program.

With respect to ACOE's evaluation of an in-situ immobilization approach, continuation of the flushing program will provide the ability to transition to an approach to stabilize uranium leaching to the partially saturated zone through an augmentation program if determined appropriate. The augmentation program may be implemented at the appropriate time when it can be most effective, after flushing has been completed. Figure 3 illustrates the potential benefit of an augmentation approach.

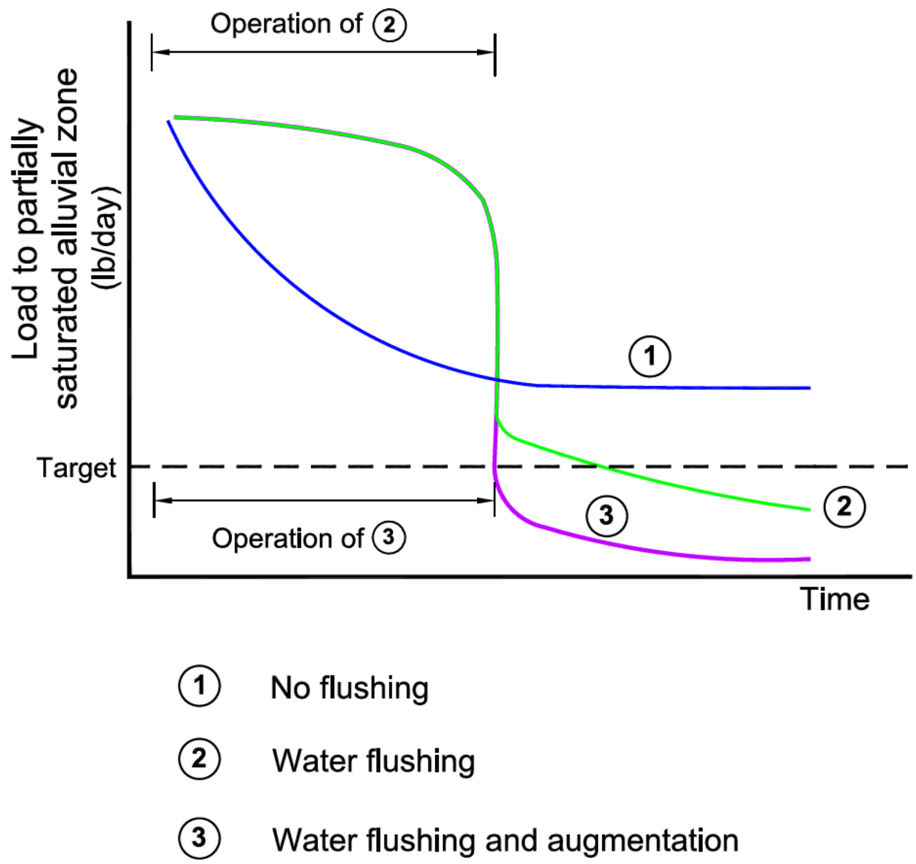


Figure 3. Conceptual remedial performance of the large tailings pile with and without flushing, and with flushing and an augmentation approach.

Because of the known occurrence and relatively low permeability of fine-grained materials (slimes) in the large tailings pile, and the presence of dissolved uranium in the slimes, an option is to create insoluble forms of uranium through the addition of a phosphate amendment. A preliminary geochemical modeling evaluation has been performed for the current uranium chemistry prevalent in the large tailings pile. The aqueous geochemistry data for wells EH-11 and EH-13 indicate that the prevalent forms of uranium in the tailings are soluble uranyl carbonates (Figure 2). A phosphate amendment (HPO_4^{3-}) was simulated and the minerals and aqueous species with a phosphate treatment solution were found to be stable over most of the pH range. This was simulated through a geochemical modeling evaluation of the addition of phosphate to the tailings (Figure 4). These initial conclusions suggest that the flushing of the tailings should be continued to remove the soluble uranium present in the slimes, then the remaining low levels of uranium could be fixed by introduction of a phosphate amendment to form insoluble uranium phosphate minerals, or another amendment that is proven to assist in remediation. The modeling results, therefore, validate that an in-situ immobilization approach using sodium tripolyphosphate (reviewed by the ACOE in Section 4.4.3) is feasible; this will be further evaluated for application to the partially saturated alluvial zone underneath the tailings, and for groundwater where the geochemical conditions are also suitable for its application.

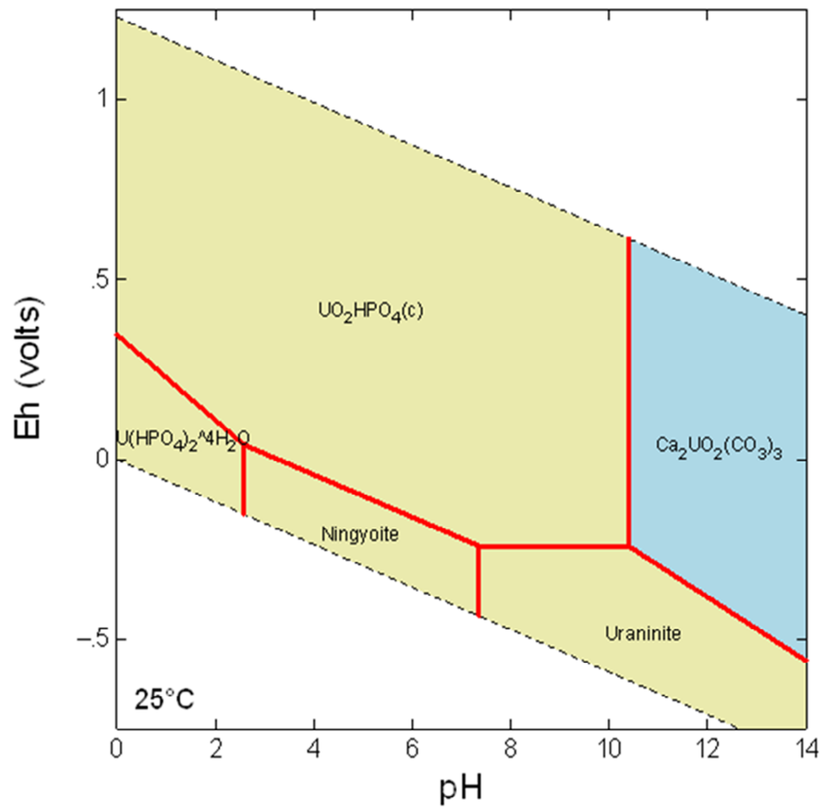


Figure 4. Evaluation of the addition of 1 mM (30 mg/L) of phosphate to the tailings pore water (water chemistry provided in Table 1). The result of the phosphate addition is precipitation of uranium as $UO_2HPO_{4(c)}$, an insoluble uranium phosphate mineral phase (yellow shaded region on the figure shows the stability field of solid forms of uranium; the blue shaded area shows the stability field of soluble uranium). Note that the y-axis shows Eh, or a measure of the oxidation-reduction potential (redox).

In summary, HMC does not believe that the recommendation that tailings flushing be curtailed, or discontinued, will lead to a better strategy for uranium source reduction in the large tailing pile. The current source reduction strategy is based on the understanding that the majority of uranium in the tailings resides as soluble uranium in the pore water, and must be hydraulically forced out of low permeability zones to effect capture and removal. The flushing program has shown significant progress (as detailed in our response to Recommendation No. 2, below) and should continue in order to meet remedial targets. It is highly unlikely that a significant amount of uranium will be present in a form capable of dissolution upon conclusion of the flushing program, due to the tailings pore water chemistry that favors soluble uranium, and that prevents sorption and retention by solids. In addition, an aggressive milling process mobilized the soluble uranium in the ore, and any remaining insoluble uranium will not be mobile. HMC, therefore, strongly disagrees with the ACOE recommendation and believes that flushing is the most proactive source reduction option available and to achieve the remediation targets in a timely manner. We request that Recommendation No. 1 be removed from the final RSE report.

Recommendation No. 2 - Simplification of the extraction and injection system is necessary to better focus on capture of the flux from under the piles and to significantly reduce dilution as a component of the remedy.

HMC Response:

HMC believes that the current flushing and extraction system at the large tailings pile has been effective in removing a substantial amount of uranium and other constituents from the tailings that would otherwise be available to enter the alluvial aquifer. The ACOE's recommendation to simplify and better capture the flux under the pile has some merit and HMC plans to re-evaluate the existing system to possibly achieve more efficient mass removal of the constituents. The success of the existing system should not be underestimated, however. The hydraulic head created by the flushing forces uranium in otherwise immobile pore spaces to move out into the zones where it can be mobilized. Without flushing, this driving force would not exist. The following briefly discusses the effectiveness of the tailings pile flushing and extraction system over the last 16 to 18 years and evaluations that HMC may undertake to assess mass recovery.

The effectiveness of the combined flushing and extraction system can be measured by the mass of uranium removed from the tailings. A graph of the total mass of uranium removed by the toe drains along the perimeter of the tailings pile and extraction wells in the tailings since 1992 is provided as Figure 3. The toe drains began in 1992, whereas the extraction wells began operation in 1995. The cumulative mass of uranium removed from the tailings reached approximately 170,000 pounds by the end of 2009, and the removal rate has been relatively steady through time, indicating that the system continually removes a substantial amount of uranium in addition to other constituents such as sulfate, molybdenum, and selenium that also have similar and steady removal rates. This amount of uranium is no longer available to leach and migrate into the alluvial aquifer.

Added to the uranium removed by the tailings extraction wells and toe drains, a considerable amount of uranium has been flushed from the tailings and partially saturated alluvial zone beneath the tailings pile. This flushing through the partially saturated zone is vital to the success of mass removal; this mass flux beneath the pile is, or will be, ultimately removed by collection wells south and west of the pile. The amount of uranium is approximated by multiplying the average flushing rate through the partially saturated alluvial zone of approximately 150 gallons per minute (gpm) by the average uranium concentration in the tailings of 30 mg/L and summing this over the 1992 through 2009 period. The resulting mass of uranium flushed from the alluvial zone is approximately 350,000 pounds. In total, approximately 520,000 pounds of uranium is estimated to have been removed from the tailings pile.

The effectiveness of the system is also measured in the overall reduction in uranium concentration within the tailings pile. The annual average uranium concentrations in the extraction wells and toe drains are shown on Figure 5. Uranium concentrations from the extraction wells have decreased from around 40 to 14 mg/L, or an approximate 65 percent reduction since 1995. The decrease in concentrations from extraction wells is steady. A regression trend line was fitted to the extraction well concentration data with a coefficient of determination (R^2) value of 0.85. The coefficient of determination provides a measure of how well future outcomes are likely to be predicted by the model, and in this case the linear regression line. A value near 1.0 indicates that the regression line perfectly fits the data, and the 0.85 value indicates a good fit. The uranium concentration in the toe drains has decreased from 53 to 30 mg/L, or an approximate 34 percent reduction since 1992. The uranium concentration has fluctuated through time but it has an overall decreasing trend, as depicted by the linear regression line that has an R^2 of 0.61. It is important to point out that the toe drains primarily remove tailings water from the permeable sand dikes, and this has not been the focus of flushing remediation to date. Instead, the focus has been on flushing the tailings slimes through the injection and extractions wells, which addresses the low-mobile mass that is difficult to remove. After the mass is removed from the slimes, the system can then focus on the mobile mass in the tailings sands and this is expected to occur relatively quickly. Overall, the system continues to remove uranium and other constituent mass, and concentrations are steadily decreasing.

The ACOE's recommendation states that "dilution" is a significant component of the current remedy. HMC believes that a minor degree of dilution may be occurring, but dilution is not as significant as implied by the ACOE. This is evidenced in the mass of uranium removed and concentrations presented on Figure 5. If dilution was a significant component of the remedy, the mass removed would not have a steady cumulative rate as it has had since 1992; instead, the mass removal would taper off or flatten. Therefore, the fact that mass continues to be removed at a relatively constant rate combined with concentrations that are decreasing is evidence that dilution is a minor component.

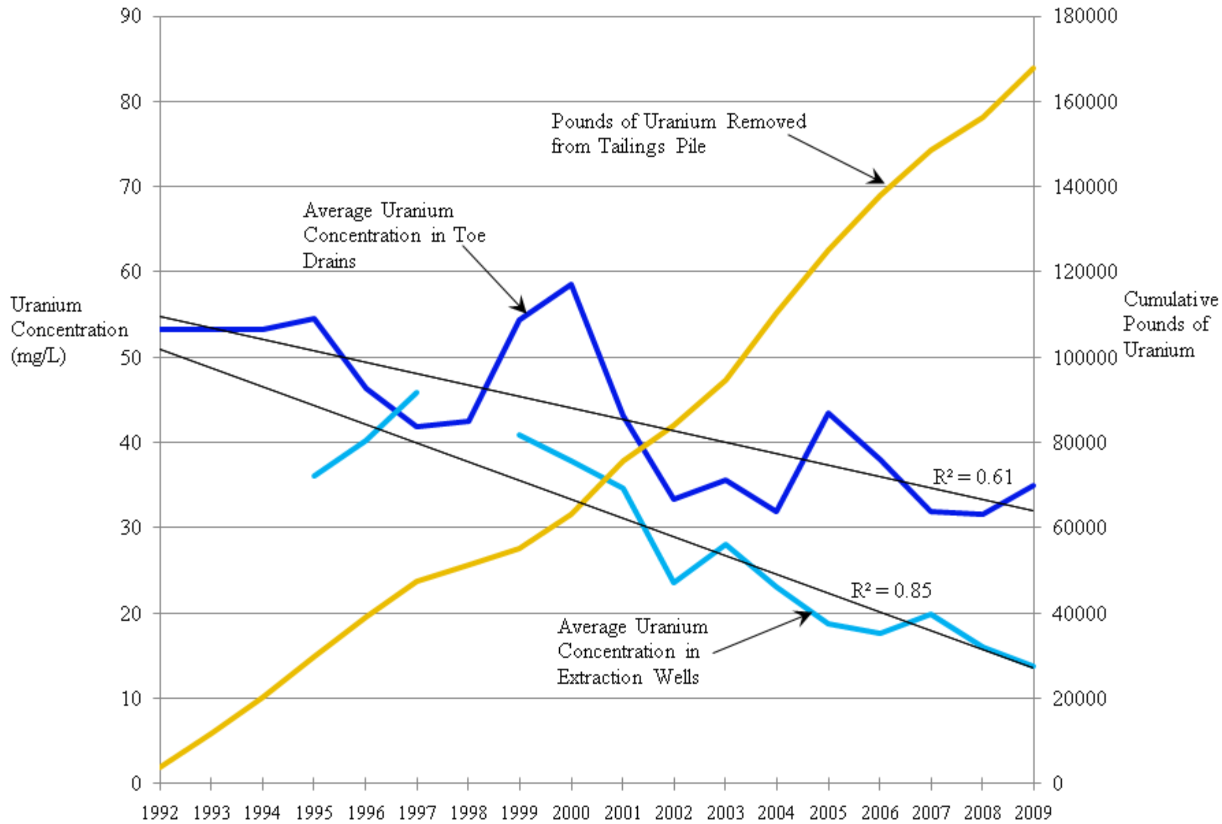


Figure 5. Mass of uranium removed by the large tailing pile extraction wells and toe drains and decreasing uranium concentrations.

To address the ACOE's recommendation regarding simplification of the system, HMC plans to evaluate the system and how it is managed and operated. The evaluation may include recommendations for future modifications to the system operation, should they be found to increase the effectiveness of the system to reduce constituent concentrations and capture of tailing seepage. The following describes evaluations that HMC may perform.

Water Balance - HMC plans to use available data to prepare annual water balances for the large tailings pile since the late 1990s. Data for the volume of rinse water, extracted water, and toe drain water will be used to approximate the amount of water that may flow out of the tailings pile into the alluvial aquifer. This type of a water balance evaluation has been done in the past, and it will be re-examined and expanded to create a historical perspective on the tailings pile water balance. The water balances provide information on how much water is flushed through the partially saturated alluvial zone beneath the tailings pile. It is important to realize, however, that a certain amount of water is needed to flush the partially saturated zone beneath the tailings pile to flush mass from this zone into the alluvial aquifer, where it can be extracted by collection wells around the perimeter of the tailings pile. This can only be achieved by allowing some of the flushing water to flow through the partially saturated zone beneath the tailings pile.

Mass-Flux Evaluation - Building on the water balance evaluation above, HMC plans to perform a mass-flux evaluation of the large tailings pile. Flux-informed evaluations are useful in characterization and aid in remedial decision making. The first component of the evaluation is to estimate the mass of constituents stored in the fine-grained tailings (slimes) and in the coarse-grained tailings. This provides an understanding of the "mobile" mass that can be remediated using the current flushing and extraction system. The mass stored in the fine-grained tailings is less mobile, and the evaluation may find that flushing of the fine-grained tailings could be curtailed or eliminated because of its very low mass flux. The hydraulic flux (pumping) at each injection well and mass flux (concentration x pumping rate) at each extraction well will be estimated to provide information on where the highest flushing rates occur and the relationship to where the greatest mass removal occurs. The goal of the mass-flux evaluation is to optimize the mass removal rate. Results of the mass-flux evaluation may identify wells or certain areas of the tailings pile where flushing could be curtailed.

Recommendation No. 3 - Further evaluate capture of contaminants west of the northwestern corner of the large tailings pile.

HMC Response:

The saturated thickness of the alluvial aquifer northwest of the large tailings pile is limited, and the zero saturation line is less than approximately 1,000 feet northwest of the pile. Previous testing in this area indicated that well yields of greater than 1 gpm could not be sustained, which prohibits effective extraction. Therefore, several fresh water injection wells and injection lines were installed west of the pile to create a hydraulic barrier and limit the westerly migration from the large tailings pile. The injection also increases the saturated thickness of the alluvial aquifer in the area. The hydraulic barrier is illustrated on Figure 4.2-1 of the 2008 Annual Monitoring Report (HMC and Hydro-Engineering, LLC. 2009) where the water in the area of injection is approximately 10 feet higher than at the western toe of the tailings pile. The other remedial component in this area includes collection wells between the toe of the tailings pile and the injection wells/lines. The injection combined with collection near the toe of the tailings pile has been effective at remediating the alluvial aquifer west of the large tailings pile. Without the injection the collection wells alone would have limited effectiveness.

The ACOE's recommendation to further investigate capture of constituents west and northwest of the large tailings pile may have value. However, HMC must point out that this is a relatively small portion of the site that has minimal potential exposure to residents or workers. HMC plans to assess the available injection/collection data, water levels, and chemical data in these areas and re-evaluate the effectiveness of capture system. The increased saturated thickness due to fresh water injection could have altered local groundwater flow directions resulting in some bypass of tailing seepage around the hydraulic barrier created by the injection. Because the zero saturation line for the alluvial aquifer is a relatively short distance northwest of the tailings pile, the focus of the re-evaluation should be the area west of the tailings pile. Adjustments to the existing injection/collection system may be considered to achieve more effective capture.

Recommendation No. 4 - If not previously assessed, consider investigating the potential for contaminant mass loading on the ground water in the vicinity of the former mill site.

HMC Response:

HMC is uncertain of the basis for this recommendation because demolition of the mill and cover of former mill area is well-documented. The former mill and associated structures were decommissioned between 1993 and 1995, which was approved by the U.S. Nuclear Regulatory Commission (NRC). Beginning in 1993, the major mill structures were demolished and the debris was buried on site in a total of eight pits. Five of the eight pits were in the mill area between the large tailings pile and State Road 605, and the remaining three pits were between the large tailings pile and evaporation ponds #1 and #2. Demolition debris primarily consisted of metal and wood from buildings, milling equipment including thickeners, roasters, and dryers, and concrete foundations. Pits were typically 20 feet deep and debris was placed into the pits in 5-foot lifts. After each lift was in place, a slurry grout was pumped into the pit to fill voids around the debris and solidify the debris. Once filled, a soil cover was place over the pits and surrounding areas and graded for positive drainage. The soil cover was approximately 2 feet thick over the mill area, but the cover was thicker (4 to 5 feet) over some of the pits. A diversion levee north of the mill area was also constructed to divert runoff from flowing over the mill area. A gamma survey was performed after the cover was in place to measure the effectiveness of the cover to restrict radionuclide emissions. As-built and completion documents are contained in Completion Report – Mill Decommissioning, Homestake Mining Company, Grants Uranium Mill, February 29, 1996. Quality control of earthwork and cover construction is documented in a Construction and Quality Control Report by Knight Piesold, May 17, 1996.

The slurry grout that was used to solidify the mill debris in the burial pits is believed to have effectively entombed the debris and prevented its contact with the surrounding environment. This solidification, combined with the engineered cover and storm water controls that limit percolation of water through the pits, significantly restricts potential leaching of uranium and radionuclides from the debris. The depth to water in the alluvial aquifer at the former mill is approximately 35 feet on average and deeper at approximately 50 feet between the large tailings pile and the evaporation ponds, where pits #4 and #5 are located. Considering that the pits were typically 20 feet deep, the bottoms of the pits are 15 to 30 feet above the water table. Potential leaching of the solidified debris in the pits would have to first migrate through this unsaturated zone before reaching the water table. Given the low precipitation in the area and storm water run-on and run-off controls, it is highly unlikely that leaching of the stabilized debris is a source of contaminants to the alluvial aquifer.

A cluster of alluvial monitoring wells is located southeast of the former mill and south of several of the pits at the former mill site. Uranium concentrations in this area are variable over short distances. This is in an area where an *in situ* biological test is situated with associated water injection, which may be the source of some of the variability. The source of the elevated uranium is believed to be residual tailings seepage from the large tailings pile. However, injection south of this area has created a groundwater "high" and the groundwater flow direction in the alluvial aquifer is to the west. Collection wells in the area west of the mill also facilitate this westerly groundwater flow. Therefore, alluvial groundwater in the former mill area should flow toward the collection wells between the large tailings pile and evaporation pond #1. Burial pits #4 and #5, which are between the large tailings pile and the evaporation ponds, are also in this area of groundwater collection.

Evidence for this westerly flow direction is from concentration observations in alluvial well 1M, which is south of the mill between evaporation pond #1 and State Road 605. The 2008 uranium concentration in the well was 0.013 mg/L, and other constituents including molybdenum and selenium, were not detected. If there was a southerly flow direction from the mill and burial pit at the mill site, concentrations would be much higher in well 1M, but this has not been observed.

There are numerous monitoring wells in the former mill area and the injection and extraction system is controlling the migration of any site-related constituents. In the unlikely event that the stabilized mill debris in the pits produces leachate, the leachate would be collected in extraction wells west of the mill. For these reasons, HMC does not believe that additional investigations of the mill area are necessary and the ACOE's recommendation should be removed from the final RSE report.

Recommendation No. 5 - Further investigate the extent of contaminants, particularly uranium, in the Upper and Middle Chinle aquifers and resolve questions regarding dramatically different water levels among wells in the Middle Chinle.

HMC Response:

The ACOE's recommendation to further investigate uranium concentrations in the Upper and Chinle aquifer is inconsistent with its interpretations stated the Draft RSE Report. Section 3.5, Page 16 states: "*Performance for the extraction system in the Upper Chinle aquifer appears to* *be adequate.*" It is unclear why the ACOE recommends further investigation of the Upper Chinle aquifer when it interprets the performance of remediation in the Upper Chinle aquifer to be adequate. The performance is presumably based on an adequate level of monitoring in the area, yet there is a recommendation for further monitoring. HMC agrees that the collection and fresh water injection system in the Upper Chinle aquifer is performing well, as documented in the 2008 Annual Monitoring Report (HMC and Hydro-Engineering, LLC. 2009). As depicted on the water level elevation map on Figure 5.2-1 of the report, the collection wells in the Upper Chinle aquifer immediately south of the large tailings pile effectively create a hydraulic capture zone that collects groundwater with elevated uranium and other constituents. This collection system, combined with the fresh water injection further to the south between the collection wells and Broadview Acres, controls the off-site migration as shown on the uranium iso-concentration contour map, Figure 5.3-11 of the report.

A number of Upper Chinle aquifer wells are strategically positioned on site to monitor potential migration from the large tailings pile, evaporation pond #1 and #2, and the small tailings pile. Monitoring wells are also located downgradient and off site in Broadview Acres and Felice Acres. Areas that exceed the site uranium standard in the Upper Chinle aquifer are limited to the large tailings pile south to the collection pond and #2 evaporation pond, and localized areas in Broadview Acres and Felice Acres. However, an adequate number of wells surround each of these areas and, when combined with an understanding of the groundwater flow direction that is depicted on Figure 5.2-1 of the Annual Monitoring Report, the extent of uranium is defined.

As discussed below, ACOE's recommendation to resolve the difference in water levels among wells completed in the Middle Chinle aquifer is not warranted and further investigation of the extent of uranium is also not needed as discussed below.

First, the variable water levels in the Middle Chinle aquifer are adequately explained in Section 6.2 of the 2008 Annual Monitoring Report (HMC and Hydro-Engineering, LLC. 2009) and are summarized below. As illustrated on the water level map of the Middle Chinle aquifer in the report (Figure 6.2-1), steep gradients occur along the alluvial subcrop south of Felice Acres, which are due to recharge of water from the alluvial aquifer. Collection of water from CW-1 and CW-2 immediately north of the large tailings piles lowers water levels by 20 to 30 feet and creates a zone of hydraulic capture near the pile. Another area of large differences in water levels is north of Broadview Acres and southwest of Felice Acres where the injection of fresh water into wells CW14 and CW30 has created localized groundwater mounds in the areas of these wells that are approximately 50 to 70 feet higher than water levels that are farther away from the injection. The west and east faults that bound the site influence water levels by restricting flow, which results in lower water levels between the two faults. Groundwater does not readily flow across the faults. The 2008 Annual Monitoring Report contains water level hydrographs of select wells (Figures 6.2-3 and 6.2-4), and the variable water levels shown on the graphs may be the source of the ACOE's comment on the alleged "dramatically" different water levels. However, the variable water levels in collection wells are explained by measurements taken during times of pumping and non-pumping when water levels have recovered. Some of the variation in water levels is also explained by variable pumping rates in some of the collection wells. There is a noticeable difference in water levels in wells west of the west fault that are 80 to 100 feet higher than water levels between the west and east faults. These differences are explained by the west fault restricting flow across the fault. A closer review by the ACOE of the site's hydrogeology and operation of the injection and collection system in the Middle Chinle aquifer would have found that the differences in water levels can be explained.

The second recommendation by the ACOE is to further investigate the extent of uranium in the Middle Chinle aquifer. As shown on Figure 6.3-11 of the 2008 Annual Monitoring Report, uranium concentrations greater than the site standard are limited to an area west of the west fault, in Broadview Acres and south of Felice Acres, and immediately north of the large tailings pile, although this area is minimally above the site standard. The area west of the west fault has wells surrounding the location of elevated uranium in CW-17, and the area is physically bounded on the west by the zero saturation restriction and the west fault. The elevated uranium concentrations at Broadview Acres and Felice Acres is bounded by wells to the east, fresh water injection on the west, and the subcrop extent of the Middle Chinle formation on the south. The localized area of elevated uranium immediately north of the large tailings pile is in an area of hydraulic control due to groundwater collection.

Overall, the large differences in water levels that are pointed out by the ACOE can be explained by the site's complex hydrogeology, geologic structure, and operation of the injection and extraction system. HMC believes that the existing monitoring of the Upper and Middle Chinle aquifers is adequate from a site-wide perspective and for areas where constituent concentrations are greater than site standards.

Recommendation No. 6 - Consider geophysical techniques, such as electrical resistivity tomography to assess leakage under the evaporation ponds.

HMC Response:

The ACOE states in Section 4.3 that there is no obvious evidence of leaks in the evaporation ponds, and evaluated this by comparing water levels in the ponds and in nearby wells. Except for the error noted in the top of casing elevation for some of the C series wells (this was a database error that has been corrected), the water levels did not indicate any leakage. While Evaporation Pond 1 (EP-1) does not have a leak detection system, Evaporation Pond 2 (EP-2) does possess a leak detection system and is double-lined. However, there is an active collection system of wells that would collect any water that might seep away from EP-1 in the event of a leak.

Two-dimensional (2D) resistivity might be able to ascertain the integrity of the evaporation ponds by placing multiple 2D lines tangential to the margin of the evaporation ponds to allow imaging along these margins. Fluid migrating out of the ponds would have very high total dissolved solids and are, therefore, highly conductive. However, the geophysical survey would not be able to provide any information on leakage rates and would therefore not provide useful information. Given that the technique could not provide information on the magnitude of the leakage (e.g., flow rates), the results would not be actionable relative to altering the current strategy. Additionally, water flowing into, within, and around the ponds create self potentials (electric field induced naturally by the water) which would induce electrical noise into the geophysical measurement and significantly reduce the accuracy of the survey. Two-dimensional resistivity would not provide information on the area directly beneath the ponds due to the inability to run lines directly across them. Any vertical fluid loss would not be detected.

A better approach is to examine water levels in the pond and adjacent wells; this was evaluated by ACOE and, as discussed above, did not show any evidence of leakage. Currently, the flow at the margins of the evaporation ponds is to the wells to the northwest; therefore, any potential leakage would be collected and contained in the current collection well system south of the large tailings pile.

Recommendation No. 7 - Assure decommissioning of any potentially compromised wells screened in the San Andres Formation is completed as soon as possible.

HMC Response:

The ACOE's recommendation to decommission any San Andres Aquifer well that has a compromised screen is a good point to ensure the continued protection of the aquifer. There are 23 wells in the site vicinity that are completed in the San Andres Aquifer. About half of these wells are included in the site's monitoring program. 2008 concentration data from aquifer wells are similar to historical values; the consistent concentrations through time indicate that the aquifer is not impacted by constituents typically found in tailings seepage. This also suggests that, in the unlikely event that there is a compromised well screen, it has not resulted in cross-contamination into the deep aquifer. The ACOE apparently has this same interpretation, as mentioned in Section 3.6 Page 16 of their Draft RSE Report, which states: "*A review of water quality data and water levels for the relatively few wells screened in the San Andres Formation was conducted. Though few data were available, there was no evidence of contaminant impacts to these wells. Water levels were reasonably consistent and indicated a ground water flow direction in the San Andres toward the northeast*." The following outlines HMC's approach to evaluating potential compromised monitoring wells and supply wells.

HMC plans to review available borehole logs for San Andres Aquifer monitoring wells and identify those which have screens or gravel packs that extend up into the overlying Chinle Formation that could potentially allow from possible cross-contamination. Available water levels will also be reviewed to determine if a particular well's water level is consistent with other San Andres Aquifer wells. The aquifer is confined, and the potentiometric surface is lower than water levels in the overlying Chinle Formation and alluvial aquifer; therefore, a water level that is similar to water levels in the overlying aquifers could indicate that the well screen has hydraulically connected aquifers. HMC may also employ down-hole video to evaluate the integrity of suspect well screens. If a well is suspected of cross-contaminating the San Andres Aquifer, the well may be pumped to determine the extent of contamination. HMC has already done this at private well 986 east of Valle Verde and found that the low concentration of uranium decreased to values typical of the San Andres Aquifer (0.01 mg/L or less) after a short period of pumping. Therefore, the suspected leakage from the alluvial aquifer or Lower Chinle aquifer may be enough to slightly increase the uranium concentration in the well casing, but it is not affecting the San Andres Aquifer water quality. Monitoring wells that are proven to contaminate the San Andres Aquifer by compromised well screens will be properly abandoned in accordance with New Mexico regulations in New Mexico Administrative Code 19.27.4.31, Part K, Plugging Requirements for artesian wells. It is important to point out that some of the San Andres Aquifer wells are on private property. If found to have compromised well screens or if well screens hydraulically connect shallow and deep aquifers, abandonment of these private wells would be the responsibility of the owners, not HMC.

HMC operates two San Andres wells (#1 Deep and #2 Deep) that are used to supply the fresh-water injection systems within the collection area. Also, San Andres well 951 is used as the fresh-water injection supply for the injection system in Sections 28 and 29, and San Andres well 943 is used as the fresh-water injection supply for the injection system in Sections 3 and 35 and Felice Acres. HMC will not abandon these supply wells because they are vital to the injection system. The supply wells are heavily pumped and potential migration of constituents from shallow aquifer to the deeper is unlikely because of the pumping. Review of the water chemistry from these supply wells indicates that they are not impacted by site-related constituents such as uranium and sulfate. HMC will continue to evaluate the supply wells and, if found to have a compromised well screen that results in cross-contamination of the San Andres Aquifer, HMC may consider modifying the well screens or otherwise address the issue for that particular well.

The Draft RSE Report specifically identified well 0806 to be decommissioned because it was replaced by well 0806R. Well 0806 is located at the northern part of Murray Acres and has an opening in the casing near the water level in the Chinle shale interval. The alluvial and Lower Chinle aquifers in this area have very low uranium concentrations; thus, it is unlikely that the opening in well 0806 is affecting the San Andres Aquifer water quality. The 2008 uranium concentration in 0806R, which is about 60 feet away, was low at 0.018 mg/L and typical of other San Andres Aquifer wells. HMC is in ongoing discussions with the Office of the State Engineer to abandon well 0806.

Recommendation No. 8 - Consider construction of a slurry wall or PRB around the site to control contaminant migration from the tailings piles. The decision for implementing such an alternative would depend on the economics of the situation.

HMC Response:

Under the alternative strategies evaluated by the ACOE, construction of a slurry wall around the entire tailings pile and a permeable reactive barrier (PRB) downgradient of about half of the tailings pile are two remedial technologies recommended for additional study as alternatives to the current extraction/injection strategy. HMC has evaluated slurry walls and PRBs as possible remedial options and found them to be difficult to construct and ineffective given the site conditions and they could result in incomplete isolation and capture of tailing seepage migration. The following elaborates on slurry walls and PRBs and their applicability as alternative remedial strategies.

Construction of a slurry wall would require trenching or excavation through the entire thickness of the alluvium, which is known to reach depths of approximately 120 feet based on the available borehole information and depth to the base of the alluvium. The actual depth of a potential slurry wall would be greater than this near the southwest corner of the large tailings pile because the Upper Chinle aquifer is in direct contact with the alluvium and the wall would have to extend to the base of the Upper Chinle, which would be another 20 feet, making the overall depth of the wall closer to 140 feet. Well CE7 is in this area and it is screened in the upper Chinle aquifer from 100 to140 feet. At another site, the U. S Department of Energy (DOE) has rejected similar trenching proposals in the immediate vicinity of the pile as a permanent remedial solution.

The success or failure of a slurry wall depends on continuous placement of the low-permeability slurry through the alluvium so that it is keyed into the underlying bedrock (Chinle shale) to cut off potential groundwater flow along the contact between alluvium and shale. This would require additional excavation into the shale of at least 5 feet, resulting in a maximum depth of at least 145 feet. It is important to note that Chinle shale may have thin layers of sandstone, and the depth could be even greater to reach low-permeability competent shale.

Although trenching technologies may be feasible at such depths, it is difficult to ensure continuity of a slurry wall. During construction, the trench would be inspected for width, depth, key penetration, verticality, continuity, stability, and bottom cleaning. The EPA guidance on subsurface engineered barriers recognizes these important factors for successful slurry walls, stating that below about 100 feet the verticality and thus the continuity of grout barriers are difficult to control or confirm (EPA 1998). Another difficulty associated with slurry walls is excavating a key into the underlying bedrock. Depending on the hardness of the shale, blasting may be required. In addition to the fact that the depth of the slurry wall could reach 145 feet, the length of the slurry wall that would be required to isolate the tailings migration is estimated to be 13,000 feet or 2.5 miles. HMC knows of no slurry walls of this length and depth that have been constructed, much less successfully operated. Given that the continuity of a slurry wall is difficult to confirm at such great depths and the tremendous length of the wall, it is likely that complete continuity of the wall could not be achieved or maintained.

The ACOE cites two projects where slurry walls have been used: the 9th Avenue Dump in Gary, Indiana and Lipari Landfill in Glassboro, New Jersey. The 9th Avenue Dump is located in a marsh area with a shallow water table and the slurry wall was about 30 feet deep. The Lipari Landfill is in a similar setting and the slurry wall was also about 30 feet deep. These two sites are significantly different from the Grants site, where the depth of a slurry wall would be nearly five times greater. Therefore, these two sites are not appropriate references for the Grants site, where the slurry wall could be more than 145 feet deep in certain places.

A PRB would suffer the same difficulties and uncertainties as a slurry wall. The trench for the PRB would have to be excavated to depths of up to 145 feet and also keyed into the underlying Chinle shale. The PRB that ACOE evaluated was a funnel and gate barrier, where two slurry walls would be used to direct groundwater to an 800-foot long gate or PRB where the water would be treated *in situ*. Installing a PRB to depths of 145 feet would be technically challenging with a high potential for failure. Unlike a slurry wall, where the slurry is used to keep the excavation open, the continuity of the reactive material forming the PRB would likely be compromised by sloughing of excavation when the reactive material is put in place. Furthermore, PRBs are prone to clogging as constituents, in this case uranium and other dissolve inorganics, would precipitate within the PRB. This would lead to reduced permeability of the reactive barrier, as the ACOE correctly mentions (citing information from a PRB installed at the Denver Federal Center in Lakewood, Colorado) and over time, the PRB may have to be replaced. Replacement costs were not factored into the ACOE cost estimate of $19,000,000. The PRB at the Denver Federal Center has also experienced other problems of reduced permeability that occurred during trench excavation. The trenching equipment created a smear zone along the sides of the trench that reduced the permeability such that groundwater mounded behind the PRB. This smearing, in all likelihood, would also occur at the Grants site, and it would be difficult to monitor and prevent at a depth of 145 feet. As mentioned by the ACOE, a PRB would need future maintenance or replacement, which is contrary to DOE’s desire to have no long-term legacy remediation maintenance requirements. Such proposals are in direct opposition to DOE’s preference for passive remediation systems at uranium mill tailings sites (see 40 CFR Part 190, Appendix A, Criterion 12).

The ACOE cites a PRB at the Fry Canyon site in Utah that was installed to remove uranium from groundwater. The PRB used three reactive materials: zero-valent iron, ferric iron, and phosphate, with the zero-valent iron having the highest uranium removal percentage. A funnel and gate method was used where the PRBs, or gates, were 3 feet thick, 7 feet wide, and about 4 feet deep. Although the PRBs had high uranium removal rates, the shallow depth of only 4 feet made the PRBs a very viable and constructible remedial option, whereas the depth of a PRB at the Grants site would be up to 145 feet, or potentially deeper. In fact, the Fry Canyon study cited by the ACOE (EPA and U.S. Geological Survey [USGS] 2000) states that PRBs have been installed at depths of no more than 45 feet. This acknowledgement by EPA and the USGS substantiates the difficulty and impracticability of installing deep PRBs.

The ACOE notes that there is a potential for migration of contaminants through the Upper Chinle aquifer that subcrops under the large tailings pile. This potential would still exist if a slurry wall or PRB is constructed and may require continued extraction and treatment of groundwater.

HMC has evaluated the economics and implementability of a slurry wall and PRB and found them to be impractical and cost-prohibitive remedial options given the difficulty of construction and likelihood of incomplete isolation or collection of the alluvial groundwater because of the excessive depth of excavations. As noted by the ACOE, there would still remain a potential for migration into the Upper Chinle Formation that would require continued extraction of groundwater. Therefore, HMC believes that the current extraction and injection remediation strategy is the most cost-effective alternative, and the difficulties associated with constructing an effective slurry wall or PRB limits these technologies from further consideration. The ACOE's recommendation for further evaluation of slurry walls and PRBs should be removed from the final RSE report.

Recommendation No. 9 - Relocation of the tailings should not be considered further given the risks to the community and workers and the greenhouse gas emissions that would be generated during such work.

HMC Response:

HMC agrees that relocation of the tailings should not be considered further. HMC also believes that it is important to re-emphasize that this "Alternative Strategy" would create a significant risk to human health. The ACOE's analysis reveals that at least three fatalities may be caused due to transport of tailings on public roadways; it is likely that the loss of life would be even greater due to the use of heavy trucks and limited maneuverability of these trucks under heavy load. While the concern over carbon dioxide emission is also stated, and placed as a consideration of paramount importance in recommending against this alternative, it is clear that the very real potential for loss of multiple human lives should be first and foremost, and enough to discount this alternative.

Recommendation No. 10 - If geotechnical considerations allow, consider expansion of the evaporation pond on the small tailings pile as means to enhance evaporative capacity.

HMC Response:

The recommendations provided with respect to the expansion of evaporative capacity or reduction in discharge to the ponds are clearly based on an understanding by the ACOE that additional evaporative capacity is needed for optimal functioning of the remedial system. This has also been recognized by the State of New Mexico, with the recent approval of DP-725 for the construction of EP-3. In light of this, the recommendation to expand the evaporation pond on the small tailings is not appropriate. In addition, expansion would be difficult due to geotechnical considerations. The expanded pond would need to be tied into EP-1; this would pose a geotechnical challenge and would possibly compromise the liner system of EP-1.

Recommendation No. 11 - Consider either the pretreatment of high concentration wastes in the collection ponds as is currently being pilot tested, or adding RO capacity to increase treatment plant throughput and reduce discharge to the ponds.

HMC Response:

This recommendation is based on an evaluation by ACOE of the reverse osmosis (RO) treatment plant, and is provided as a means to enhance the operation of the remedial system so that the plant can operate at full capacity. As with Recommendation No. 10 above, the ACOE recognizes the need for enhanced evaporative capacity and pond storage. The RO treatment plant will be able to operate at its full potential, with the recent approval of DP-725, and additional RO capacity is therefore not needed in order to increase plant throughput. HMC continues to evaluate the pre-treatment of water in the collection pond through the addition of extracted tailings water, with elevated concentrations of bicarbonate, and groundwater containing elevated concentrations of calcium. The purpose of the pre-treatment is to facilitate the precipitation of calcium carbonate and to limit the need for this treatment at the RO plant.

Recommendation No. 12 - Develop a comprehensive, regular, and objectives-based monitoring program. Quantitative long-term monitoring optimization techniques are highly recommended.

HMC Response:

HMC agrees that the monitoring program for the Grants site should be comprehensive and based on specific objectives for particular areas of the site, as well as for the entire site. Currently, HMC performs substantially more monitoring than what is required under existing permits. Approximately 80 monitoring wells are required to be sampled, but as needed, HMC voluntarily samples several hundred additional wells to assess the performance of the injection/collection systems and extent of impacted groundwater. This demonstrates HMC's commitment to the remediation of the Grants site.

The ACOE's recommendation to optimize the monitoring program has potential benefit in the long term to determine if the monitoring well network can be streamlined while still meeting the future needs of the project. HMC plans to evaluate the site groundwater monitoring program, which includes identifying and categorizing wells and their intended purpose, followed by evaluating each monitoring well and determining its inclusion or exclusion in the monitoring program. HMC plans to perform this procedure for those monitoring wells that are required under state permits or federal license as detailed below.

Define Monitoring and Develop Objectives - The first step includes identify monitoring wells at the site and pertinent information associated with each well; including date drilled, depth, casing size, screened interval and formation, location, and any possible issues with the well. Additional information, such as period of chemical and water level data and frequency of sampling, will be summarized for each well. The original and current objective of each monitoring well will be identified or formulated if the purpose of the well is uncertain. The relative location of a particular well to a source area, such as the large tailings pile, will be used to assist in developing the monitoring objectives. The outcome of this first step is a comprehensive tabulation of monitoring well information and objectives of the monitoring.

Monitoring Optimization - The second step in the planned process consists of analyzing historical data using simple statistical methods and a rule-based decision process to determine if continued or additional sampling of the existing monitoring wells will provide data relevant to characterization of known impacts. The planned analysis compares historical data collected from monitoring wells to the most recent round of sampling. Recent and long-term data will be evaluated using a simple rule-based decision process to determine an adequate sampling frequency based on intrawell concentrations of the selected constituents. HMC plans to use simple and widely accepted statistical tests that have been applied successfully on numerous contaminated groundwater sites. Several lines of evidence may be evaluated to determine if monitoring well sampling parameters and frequency are suitable. These include:

- Number of samples collected since the installation remediation started,
- Frequency of detection in recent sampling events,
- Maximum detected concentrations,
- Concentration-time profiles for the full and recent datasets,
- Magnitude of the annual concentration change with respect to important health protection, levels (i.e., site standard), and
- Predictability/variability of the concentrations over time.

Each well is then subjected to a decision process, and Figure 6 is an example of a commonly used systematic approach for evaluation and optimizing a monitoring program. Data sets are first evaluated to determine that sufficient samples have been collected. Historical and recent trends are evaluated to identify both long-term and short-term concentration trends, and the direction and magnitude of the trend can be evaluated using the relatively simple statistical tests. If no statistically significant trend is detected, the well and constituent is proposed for continued sampling at the current frequency. If a statistically significant trend is identified, the magnitude of change is evaluated with respect to the site standard. In this way, rapidly changing concentrations can indicate an important change in conditions of the plume. Wells with rapidly changing concentrations would be proposed for continued monitoring at the current frequency. Wells with negligible annual change, including those above the site standard, do not benefit from more frequent sampling and are, therefore, proposed for a lower frequency. Moreover, wells with recent trends that are similar to the overall long-term trends can be reduced to annual sampling. Because concentrations are predictable and more frequent sampling does not yield additional information. Final recommendations are subjected to scientific and engineering review to ensure that the proposed sampling program would continue to meet program needs and related permit requirements.

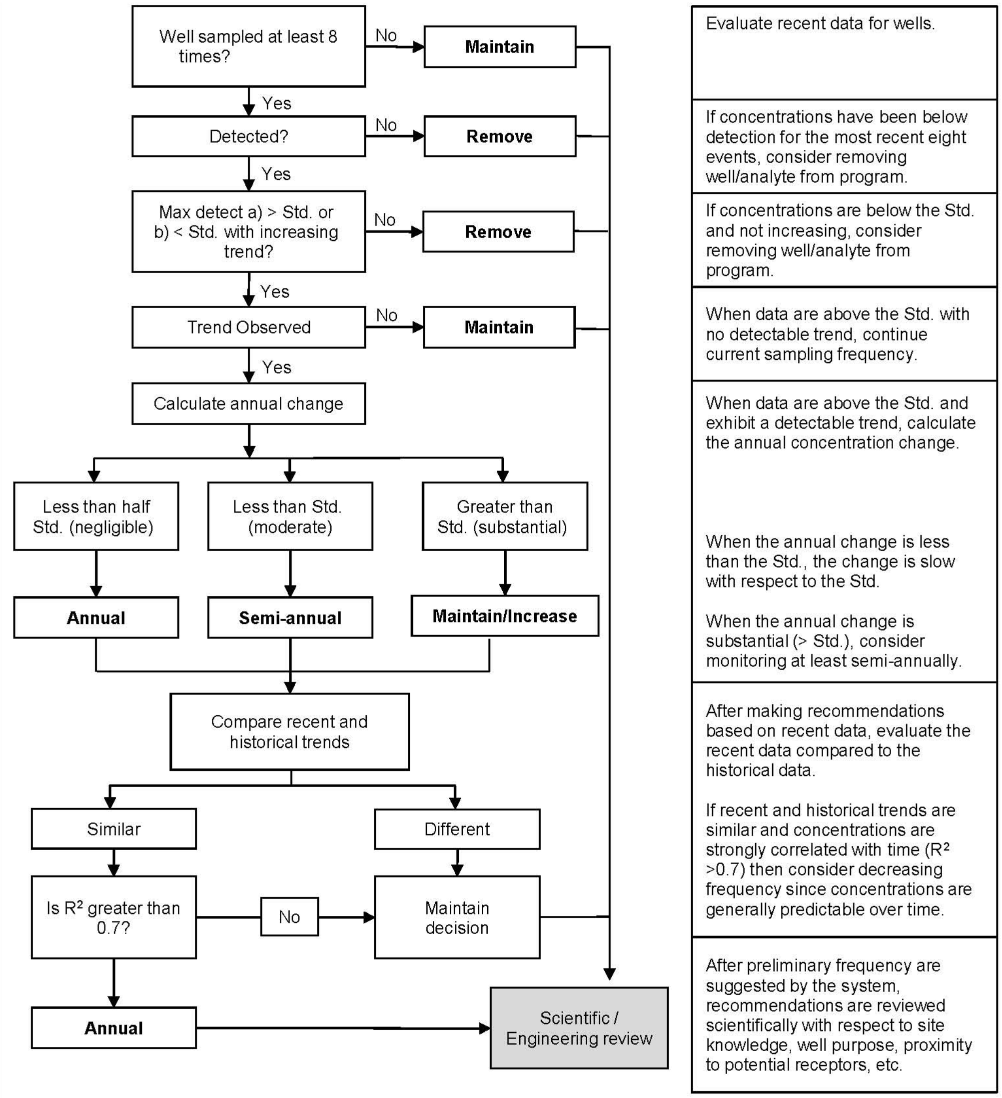


Figure 6. Decision support process for sampling optimization

Recommendation No. 13 - Adjust Air Monitoring Program to perform sampling of radon decay products to confirm equilibrium assumption, consider use of multiple radon background locations to better represent the distribution of potential concentrations and assess the radon gas potentially released from the evaporation ponds, especially during active spraying.

HMC Response:

The ACOE summary review of the monitoring program concludes that the program meets the requirements of the Nuclear Regulatory Commission Regulatory Guide 4.14 (Radiological Effluent and Environmental Monitoring at Uranium Mills). Reports detailing the monitoring results are submitted to the NRC annually. HMC does not believe that any adjustment to the air monitoring program is required with respect to the radon decay products as well as the evaporation ponds. HMC is evaluating the location of the radon background monitor, and will work with NRC on this evaluation.

The ACOE requests that wind direction data be obtained during each monitoring period; this information is collected and maintained by HMC. Attachment B provides a wind rose summarizing data collected for some of the monitoring period during 2008.

Estimate of Radon Daughters – Radon, which is released during low wind conditions, moves primarily toward the HMC #4 and HMC #5 monitoring stations. The attached wind rose data show that this occurs approximately 20 percent of the time (blue in wind rose chart). During higher wind conditions, the radon is transported primarily in other directions and is quickly dispersed. As radon ages, the concentration of radon daughters increases relative to the radon concentration (higher equilibrium). Therefore, under high wind conditions, the concentration in air of radon daughters accumulated from radon released from the site is very small, and may be higher under low wind conditions. In order to calculate a dose to the nearest neighbors, HMC selected a radon daughter equilibrium factor of 20 percent. Details of the basis for this selection are discussed here.

ACOE incorrectly suggests that the NRC Reg. Guide 8.30 specified method is appropriate for measuring the equilibrium ratio at the site. The suggested Modified Kusnetz method is a grab sample technique that would be inappropriate for use outdoors under variable wind and other atmospheric conditions. It would be difficult to interpret grab sample results because radon progeny concentrations are reduced by attaching to dust particles or scrubbed from the air by moisture. In addition, it would be nearly impossible to quantify the contribution of radon progeny from natural background radon to the measured working levels at any point near the site.

The selection of 20 percent equilibrium is a conservative estimate. If radon is released and the radon and decay products travel together toward the site perimeter, calculations show that the percent equilibrium starts at zero upon release and reaches 20 percent equilibrium after 32 minutes. In the wind rose chart for the HMC site (Attachment B), the winds represented by the "blue color" are low speed, directed toward the southwest, and thus are dominant for radon transport. They represent winds in the range of 0.5 to 2.1 meters/second. After 32 minutes, these winds would have swept the radon and daughters downwind to a distance ranging from 960 to 4,032 meters, or 3,150 to 13,200 feet. The two monitoring stations HMC#4 and HMC#5 are at approximately 2,500 feet and 3,500 feet from the large tailings pile. Therefore, the equilibrium at the farthest station (3,500 ft) would be expected to be approximately 20 percent for the 0.5 meters/second winds but less than 20 percent for the higher winds. Naturally, it is unlikely that the radon daughter equilibrium at the monitoring station at 2,500 feet would reach 20 percent for winds in this speed range. Therefore, this calculation shows that the assumption of 20 percent equilibrium is very conservative for the two monitoring stations located near the site perimeter and nearby population.

Calm winds may allow radon to reach 100 percent equilibrium if the calm persists for periods of a few hours. This air could then be driven toward the monitoring stations or in any other direction, depending on the wind direction at the time. The wind rose data indicate calm winds occur only 0.02 percent of the time and the wind rose data indicate that there would be only a 20 percent chance that the winds would sweep the stale air toward the monitoring stations (and population) to the southwest. It is therefore justified to ignore the effect of the small periods of calm winds.

The radon daughter equilibrium will be higher farther from the site, but because of dilution of radon and daughters with distance, the levels decrease significantly with distance and very quickly become indistinguishable from background concentrations.

Radon Background Locations - The ACOE suggests that the HMC consider the use of multiple radon background locations to better represent the distribution of potential radon concentrations. HMC does not agree that multiple locations are necessary or appropriate to define the background at HMC#4 and HMC#5, which are representative of the radon exposure to the nearest neighbors. The distance between HMC#4 and HMC#5 in the east-west direction is not far compared to the width of the air drainage path from the north-to-northeast direction. Thus, more than one background location is difficult to justify based on our current understanding of the air flows under calm conditions.

HMC has, however, recently questioned whether HMC#16 is representative of the true background for the site and has taken the initiative to establish additional radon monitoring stations. Air movement toward the site was modeled using an air model that considers topographic features. Point sources were input into the model were placed at selected locations and the direction of air flow during calm conditions were assessed. The result is that there are three principal drainages toward the site in which radon would be transported. The effort suggests that a more appropriate location would be in the San Mateo drainage closer to the site, where the confluence of all three drainages occurs under calm wind conditions. The new monitoring stations are located to capture all or portions of these drainages and should provide information on which to base an assessment.

It should be noted that HMC's radioactive material license specifies that HMC#16 should be used as the radon background location for the site. HMC will have to perform this assessment and present it to the NRC for review, and approval should the assessment justify a change.

Radon Emissions from Evaporation Ponds - During hearings for the renewal of DP-725, Mr. Gerard Shoeppner of the Mining Compliance Section within the Groundwater Quality Bureau of the New Mexico Environment Department testified that the majority of radon at the site originates from the tailings piles and not from the ponds. HMC has recently assessed the radon emissions from the site, including the evaporation ponds. The major sources of radon releases are primarily based on measurements, but where measurements are not available, conservative calculations were made. NRC requires radon flux measurements to be made on the large and small tailings piles annually following EPA Method 115 procedures. The averaged measured fluxes and the known areas of the piles were used to estimate the annual releases. The flux from the evaporation ponds was estimated from a model based on the assumption that the radon was in secular equilibrium with the dissolved radium-226. In order to validate the model, floating activated charcoal radon flux canisters were deployed on one of the ponds for 24 hours using EPA Method 115 analytical procedures. There was good agreement between the modeled results and measured results (to be published). For releases from the spray system, the annual HMC reported evaporation rate of 182 gpm (from Ponds 1 and 2 combined) as a result of the spray systems was used. It was assumed that radon-222 was in secular equilibrium with the measured radium-226 in the ponds, and that all of the radon in the sprayed water was released to the atmosphere. The only other radon source that was evaluated was the radon released within the RO building. In that case, the release was calculated by using the measured radon concentrations within the building and an assumed air exchange rate of 2 per hour. As can be seen from Table 2, the evaporation spray system is the least significant source of radon released from the site. Therefore, HMC believes that we have already addressed the recommendation to assess the releases from the evaporation ponds.

Table 2. Individual radon sources and annual contribution to total radon source.

Radon Source	Percent Contribution
RO Building	0.08
Surface Flux (Evaporation Ponds EP-1 and EP-2)	2.1
Spray System (Evaporation Ponds EP-1 and EP-2)	0.01
Small Tailings Pile	14.0
Large Tailings Pile	83.7

Recommendation No. 14 - Though risks appear minimal with the current irrigation practice, consider treatment of contaminated irrigation water via ion exchange prior to application as a means to remove contaminant mass from the environment.

HMC Response:

The irrigation system is an important component of the remedial systems at the Grants site. It provides an effective means of management of water that is extracted in order to control and contain the uranium plume, and enables continued progress toward meeting the groundwater remediation targets. Annual irrigation reports are published and provided to all stakeholders at the Grants site. These reports detail all aspects of the irrigation program.

HMC has previously evaluated the use of the irrigated areas based on the assumption that the HMC would make the irrigated areas immediately available to a resident farmer and that the currently used irrigation water would not be available to the resident farmer. This scenario is evaluated in the 2009 HMC Irrigation Report. Currently, the water applied to the irrigation areas is piped into the area rather than taken from beneath the irrigation areas. Therefore, only non-impacted irrigation water would be applied by the resident farmer.

Currently, the maximum uranium retention in the upper soil surface layers occurs in the Section 34 Flood Irrigation Area, where a buildup of uranium-238 of 0.69 pCi/g has occurred after approximately 10 years of irrigation. The HMC analysis using RESRAD indicates that the dose to the resident farmer is less than 0.3 millirems/year, which is insignificant.

ACOE RESRAD analysis - ACOE assumed a resident farmer scenario where uranium-238 accumulated in the top layers of soil was 10 pCi/g. A buildup of 10 pCi/g would only occur, based on historical data, after approximately 140 years of irrigation at the present rate using water similar to that which was used over the last 10 years. ACOE's analysis shows that the aquifer beneath the irrigated area would not be impacted from soils contaminated with uranium-238 at10 pCi/g. The ACOE calculated a water independent dose of 3.82 millirems, which agrees with HMC's analysis, if the doses are assumed to scale with the uranium-238 concentration.

The next part of the scenario is highly unlikely because HMC currently owns this property. ACOE assumed that this resident farmer uses contaminated water to irrigate his crops. The total uranium concentration is assumed to equal the NRC effluent limit of 0.44 mg/L. Naturally, the dose from garden vegetables grown under these conditions is relatively high with most of the dose arising from applying water directly to the garden plants. They estimate that the resident farmer would incur a dose of 18.2 millirem/year under these unlikely conditions, resulting in an estimated risk that is slightly above the EPA's desired cancer risk range for reclaimed CERCLA sites of 10^{-6} to 10^{-4} excess cancer risk.

HMC's primary concern with ACOE's analysis is with their scenario. First, HMC would not release this land for use by a resident farmer until the off-site groundwater restoration was considered complete. This is expected, however, to occur long before the approximate 140 years during which the projected uranium buildup in soil would reach 10 pCi/g of uranium-238. Second, the assumed uranium concentration of 0.44 mg/L is higher than the currently measured values in the monitoring wells in the area and thus, is unrealistically high. Most of the monitoring wells within the irrigated areas indicate that the water is below or near the uranium site standard of 0.16 mg/L.

HMC requests that Table 5 and Table 6 be removed from Section 8.1.1 of the report because they were generated based on the irrelevant and misleading irrigation scenario as described above.

Ion Exchange Pre-Treatment - Even though the conclusions of the very conservative RESRAD modeling indicate that concentrations of uranium (30 mg/kg) accumulated in the soil (under a conservative scenario) are not a risk, the ACOE recommends that ion exchange technology be used for the pre-treatment of water used for irrigation in order to remove the uranium. HMC does not believe this would improve the current irrigation system, and would be technically infeasible to implement due to the following reasons:

1) Ion exchange technology has been tested and was unsuccessful in the removal of uranium using an anion-exchange resin due to the presence of high concentrations of sulfate (~600 mg/L) and fouling of the resins due to calcite precipitation. In addition, the chemical speciation is non-ideal due to the presence of large molar excess of calcium and bicarbonate compared to uranium (see point 2, below).

2) The ion exchange technology suggested by ACOE involves products provided by REMCO Engineering (http://www.remco.com/ixidx.htm). This technology requires that uranium be present in groundwater in a form suitable for removal on an ion exchange resin (e.g., uranium must be present as the charged forms: cationic (UO_2^{2+}) or anionic ($UO_2(CO_3)_2^{2-}$). Geochemical modeling of the uranium speciation using the average concentration of species in the Grants site untreated irrigation water (Table 7 of the Draft RSE Report) as the input file (reproduced here as Table 3), shows that the uranium in the groundwater is dominated by a neutral form ($Ca_2UO_2(CO_3)_3$)(Figure 7). The neutral form of uranium would not be amenable to ion exchange, as verified by work conducted by the U.S. Department of Energy (Dong and Brooks 2006), that showed that uranium sorption onto anion-exchange resins is inhibited by the formation of the neutral $Ca_2UO_2(CO_3)_3$ species. Pre-treatment to create acidic conditions (to form UO_2^{2+}) would not be efficient due to the poor selectivity of cation exchange resins and the relatively high concentration of cations (e.g., Ca^{2+}, Na^{2+}, Mg^{2+}) in the groundwater compared to uranium. Use of a

cation exchange resin would require frequent backwashing to strip the groundwater cations and rejuvenate the resin.

Table 3. Average concentration of species in untreated irrigation water.

Constituent	mg/L	g/ mol	mM	log M
UO_2^{2+}	0.28	238	0.001	-5.92
Ca^{2+}	242	40	6.05	-2.22
Mg^{2+}	65	24	2.71	-2.57
Na^{+}	285	23	12.4	-1.91
K^{+}	8	39	0.21	-3.69
Cl^{-}	180	35	5.14	-2.29
SO_4^{2-}	840	96	8.75	-2.06
NO_3^{-}	3.5	62	0.06	-4.25
HCO_3^{-}	460	61	7.54	-2.12
Se^{6+}	0.06	79	0.001	-6.12

3) Even if uranium treatment were feasible, pre-treatment of groundwater prior to ion exchange treatment would be required to remove sulfate and to remove calcium. At least two separate pre-treatment resin beds would be required for this, in addition to the resin required to remove uranium. Regeneration would require 2 to 3 percent of the total influent volume, using regeneration brines. This would frequently create thousands of gallons of brine requiring management and disposal. If treatment occurred at a point near the irrigation, this would require the construction of a treatment plant in order to handle the resin and to accommodate the stripping operation required once the resin becomes expended. The concentrated waste material would create a significant management challenge relative to safety and human health.

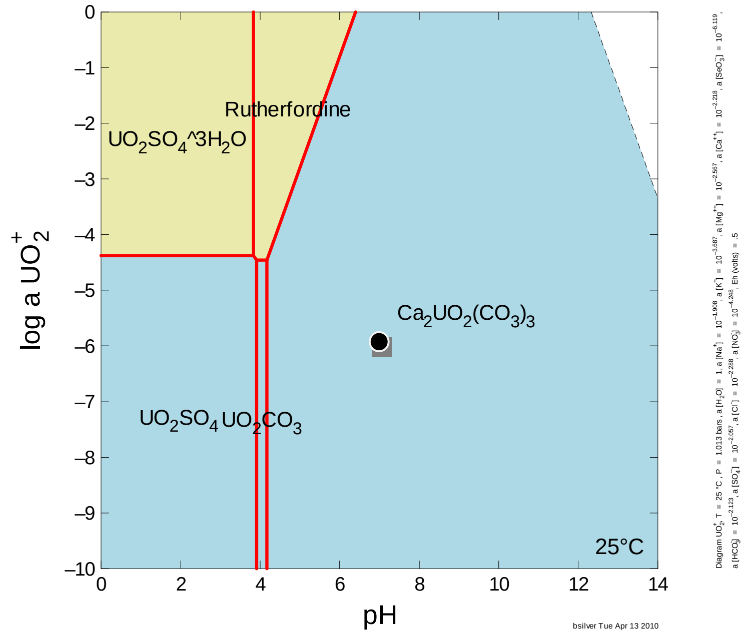


Figure 7. Predicted speciation of uranium based on the groundwater chemistry provided in Table 3. The symbol (•) on the figure shows the pH and uranium concentration relevant to the irrigation water; note that the predominant form of uranium is the neutral $Ca_2UO_2(CO_3)_3$ aqueous species. Note that the y-axis shows the uranium concentration.

Summary

The HMC Grants site has experienced significant remediation progress. HMC has aggressively worked to address the unique remedial issues at the site created by the size of the tailings pile and the number of aquifers to be addressed. In this connection, HMC has developed creative solutions to facilitate completion of remedial goals in the shortest possible time. While remediation has been ongoing for many years, the time involved is not extraordinary compared to what other complex uranium processing facilities have experienced. HMC's foregoing comments reflect a concern that the ACOE's evaluation does not reflect a full appreciation of the complexity of the Grants site, nor does the evaluation provide any innovative or positive suggestions to enhance the current remedial program. HMC is considering additional remedial techniques to accelerate remediation at the site and plans to continue its aggressive approach to finalize site reclamation.

References

Bernhard, G., Geipel, G., Reich, T., Brendler, V., Amayri, S., and Nitsche, H. 2001. Uranyl(VI) carbonate complex formation: Validation of the $Ca_2UO_2(CO_3)_3$(aq) species. Radiochimica Acta: 89 (511-518).

Delaney, J.M., and Lundeen, S.R. 1989. The LLNL Thermochemical Database. Report UCRL-21658. Lawrence Livermore National Laboratory.

Dong, W., and Brooks, S.C. 2006. Determination of the formation constants of ternary complexes of uranyl and carbonate with alkaline earth metals (Mg^{2+}, Ca^{2+}, Sr^{2+}, and Ba^{2+}) using anion exchange method. Environmental Science and Technology 40: 4689-4695.

Homestake Mining Company and Hydro-Engineering, LLC. 2009. 2008 Annual Monitoring Report/Performance Review for Homestake's Grants Project; Pursuant to NRC License SUA-1471 and Discharge Plan DP-200; prepared for U.S. Nuclear Regulatory Commission and New Mexico Environment Department. March.

Nuclear Energy Agency (NEA). 2010. Thermochemical Database Project. http://www.nea.fr/dbtdb/. Accessed April 4, 2010.

Salhotra, A.M, Adams, E.E., and Harleman, D.E. 1985. Effect of Salinity and Ionic Composition on Evaporation: Analysis of Dead Sea Evaporation Pans. Water Resources Research, Vol. 21, No. 9, September.

Skiff, K.E., and Turner, J.P. 1981. A Report on Alkaline Carbonate Leaching at the Homestake Mining Company. Report Prepared for Homestake Mining Company.

U.S. Environmental Protection Agency (EPA). 1998. Evaluation of Subsurface Engineered Barriers at Waste Sites; Office of Solid Waste and Emergency Response (5102G); EPA 542-R-98-005; August 1998.

U.S. Environmental Protection Agency (EPA) and U.S. Geological Survey (USGS). 2000. Field Demonstration of Permeable Reactive Barriers to Remove Dissolved Uranium from Groundwater, Frye Canyon, Utah, September 1997 through September 1998 Interim Report, EPA 402-C-00-001, November.

WRT. 2007. Homestake Mines, Grants, NM Phase III pilot testing results and conclusions. Technical memorandum from Charlie Williams and Scott Hefner.

Zheng, Z.G., Tokunaga, T.K., and Wan, J. 2003. Influence of calcium carbonate on U(VI) sorption to soils. Environmental Science and Technology 37: 5603-5608.

ATTACHMENT A

Inconsistencies and/or Incorrect Statements Identified in the ACOE Draft RSE Report (February 2010)

Executive Summary; page ii. A conclusion is made that there may have been widespread impacts on the general water quality (e.g., ions such as sulfate) of the alluvial aquifer since mill operations began, but the limited amount of historical data precludes certainty in this conclusion. HMC believes that this conclusion is speculation, and the Grants site does not contribute to widespread impacts. The ACOE fails to recognize that there are several alluvial systems in the Grants vicinity. The San Mateo alluvial system underlies the site with contributing water-quality effects from the Rio San Jose alluvium to the west and the Lobo alluvium to the east. It is, therefore, the combination of water quality from each of these alluvial systems that may represent any potential widespread impact, and the Rio San Jose alluvium is known to have elevated sulfate.

Executive Summary, page ii. A conclusion is made that the seepage modeling likely overestimates the efficiency of flushing of the tailings. HMC disagrees with this conclusion. Our review of the model predictions shows that the model reasonably matches observed conditions with a lag effect. This lag effect is due to reductions in extraction within the large tailings pile in recent years that was not envisioned nor included in the modeling effort.

Section 1.1, page 1. A statement is made that leaching from the mill site has contaminated groundwater. HMC is unaware of any supporting documentation that the mill site has contaminated groundwater.

Section 1.4, Condensed Overview of Site; page 3. The previous RSE report is mentioned. HMC would like to point out that this previous report was flawed and had errors in its interpretations.

Section 1.4.3, Contaminants; page 4. A statement is made that **"***Data for samples collected in the 1950s from a couple of alluvial aquifer wells approximate 2.5 miles west of the site (well numbers 0935 and 0936) suggest significant increases in sulfate concentrations have occurred*." These wells are in the Rio San Jose alluvium west of and unimpacted by the site. The inference in this section, however, is that the increasing sulfate in the wells may be due to the Grants site and it is not. Any observed increase in sulfate would be due to activities further west and upgradient of the wells.

Section 1.4.4, Extraction and Injection Systems; page 4. The extraction and injection system is stated to be not well documented. HMC disagrees with this statement. The system is sufficiently described in the annual groundwater monitoring report, which contains the volumes of water removed and injected, constituent concentrations of these waters, and maps showing the locations of system components.

Section 1.4.5, Treatment System; page 5. The RO treatment capacity is stated as 600 gpm and practical limitations are less than that. This is incorrect. The RO plant can be run at higher rates and, with the additional capacity provided by the third evaporation pond, can be operated at the 600 gpm rate or higher. The limitation is not in the clarifier section.

Section 1.4.6, Evaporation Ponds; page 5. A discussion of the evaporation ponds is presented, but is not complete. The ACOE does not mention that pond #2 has a double liner and pond #1 has a single liner. A third evaporation pond that has been approved by the NRC has just received approval from NMED.

Section 2.1.1, Conditions in the Tailings Piles; page 6. A statement is made that it is possible the uranium is not as accessible for dissolution, but it may slowly mobilize over time. The ACOE provided no basis for this statement, and our evaluations do not support it either (See HMC's response to Recommendation No. 1). This statement should be removed from the final RSE report.

Section 2.1.3, Evaporation Ponds; page 6. The ponds are stated as being a possible secondary source of contaminants affecting air, soil, and groundwater if the liners under the ponds were to leak. This statement is speculative and should be removed from the final RSE report.

Section 2.1.4, Irrigated Acreage; page 6. Irrigation with site water is stated as possibly affecting groundwater through leaching. This is contrary to the ACOE's finding in the draft RSE report that irrigation has not impacted groundwater. This statement should be removed from the final RSE report.

Section 2.2.1, Air; page 7. . It is stated that the air monitoring program at the Grants site attempts to quantify the radon in air pathway. HMC has actually gone to great lengths to "quantify" this pathway and has found that the measured radon at the site boundary primarily is from natural background sources, with only a small component originating from the site.. In fact, the EPA issued a "no action" on Radon in the Record of Decision for Grants at a point in time when the tailings piles were open and the mill was still operating. This decision was based on a comprehensive study where radon concentrations were measured in nearby homes by an independent competent scientist. The tailings piles are now covered and the mill has been decommissioned so the on-site source has been greatly reduced

Section 2.3 and Figure 2, Receptors; page 7. The text incorrectly refers to Figure 1 as the conceptual site model. The conceptual site is shown on Figure 2. HMC believes that the conceptual site model is flawed. As discussed in our response for Recommendation No. 4, HMC does not believe that the former mill area is a “Primary Source,” as depicted on the conceptual site model. Additionally, several of the exposure pathways that are indicated as complete are actually not complete. An example of this is the incomplete groundwater drinking pathway for a trespasser, resident, or worker, currently and in the future. We suggest that the ACOE re-examine this conceptual site model before issuing the final RSE report.

Section 3.2, Concentration Trends; page 13. The ACOE cites well 0882, located south of the wells used for irrigation in the northern plume, as providing evidence for incomplete capture because uranium concentrations have increased. However, the increase is only on the order of 0.02 mg/L and within typical variability of uranium concentrations in the alluvial aquifer in this area. The uranium concentration is below the site standard and below the maximum contaminant level, and the slight increase is not an indicator of incomplete capture.

Section 3.2, Concentration Trends; page 15. Well DD is discussed and the uranium concentration in the well is speculated to be a result of migration from the tailings pile. Well DD is an approved background well and the 95 percent confidence limit of uranium concentrations in the well were used to set the site standard for the alluvial aquifer. It is highly unlikely that groundwater is flowing to the north because the water level in well DD is several feet higher than at the tailings pile. Furthermore, the uranium concentration has consistently been near the 0.16 mg/L site standard level since 1995, indicating a steady source of uranium from upgradient areas, whereas the uranium concentration at the tailings pile has been decreasing over this period. If the tailings pile was the source of uranium in well DD, one would expect the uranium concentration to decrease to some degree because of the decreasing concentrations at the tailings pile, but this has not occurred.

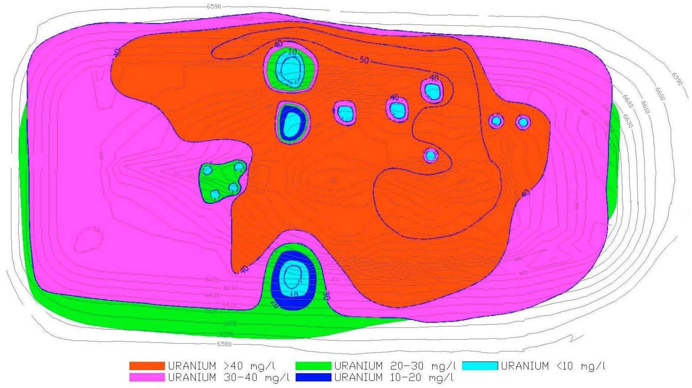
Section 3.4, Ground-Water Modeling; page 15. It is stated that the model likely over-predicts the performance of tailings flushing. A similar statement is made in the Executive Summary. HMC’s review of the model predictions shows that the model reasonably matches observed conditions; however, there is a lag effect. This lag effect is due to reductions in extraction within the large tailings pile in recent years that was not envisioned nor included in the modeling effort.

Section 3.6, Impacts to the San Andres Aquifer; page 16. It is stated that the flow direction in the San Andres aquifer is to the northeast. However, the flow direction is toward the east and slightly southeast, as shown on Figure 8.0-1 of the 2008 Annual Monitoring Report (HMC and Hydro-Engineering, LLC. 2009).

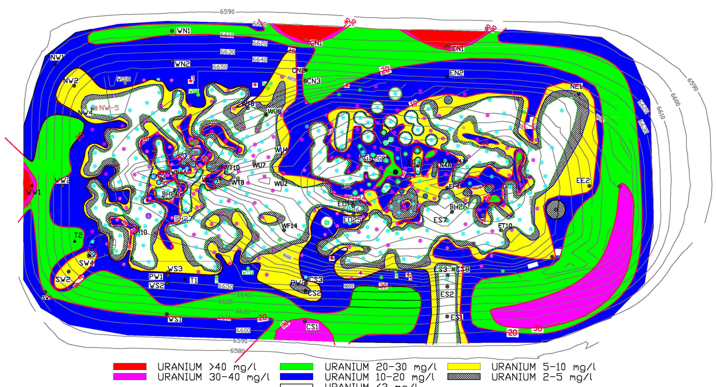
Section 4, Overall Remedial Strategy; page 17. The ACOE states that "According to Homestake, flushing of the tailings pile will be completed by 2012, with the remaining groundwater contamination completed by 2017." The last part of the sentence is worded in an awkward manner; it should read "…with remediation of the remaining groundwater contamination completed by 2017."

Section 4, Overall Remediation Strategy; page 17. The ACOEs states that "…potentially applicable replacement technologies are discussed…." Two of the possible strategies, slurry wall and PRBs are discussed. Each of these technologies is technically impracticable (see HMC's response to Recommendation No. 8). The ACOE actually provides no replacement technologies that have not already been considered.

Section 4.1 and Figure 14, Flushing of Large Tailings Pile; page 17. The flushing of the large tailings pile is discussed and Figure 14 is used to show the 2008 uranium concentrations in the tailings. Although the ACOE uses this figure to show the variability of uranium in the pile and illustrate their belief that the flushing has not been effective, HMC believes that the flushing has been effective at removing uranium mass. This is demonstrated by comparing the 2000 and 2009 maps for uranium in the tailings pile, which shows that a significant amount of uranium has been removed. See also HMC's response to Recommendation No. 2 for additional evidence of the effectiveness of the flushing and extraction program. Below is the 2000 uranium concentration map for the tailings pile showing uranium concentrations exceeding 30 mg/L in much of the pile. Also below is a map of the 2009 uranium concentrations in the pile, which illustrates the significant reduction in concentrations resulting from the flushing and extraction program. For 2009, approximately 67.5 percent of the west side slime area has uranium concentrations less than 5.0 mg/L, and 45.5 percent of the same area has concentrations lower than 2.0 mg/L.



TAILINGS URANIUM (mg/l)
2000



TAILINGS URANIUM (mg/l)
2009

Section 4.1, Flushing of Large Tailings Pile, first paragraph; Page 19. The ACOE presents a calculation of the volume of water within the tailings and bases the volume on a total porosity of 30 percent, which is not substantiated or appropriate. The mobile porosity (i.e., effective porosity) of the tailings should have been used. The slimes may have a total porosity of around 30 percent, but the effective porosity is more on the order of 8 percent and 14 percent for the tailing sands. The result of this is that the ACOE has most likely overestimated the volume of water in the tailings, which correspondingly underestimates the success of the flushing and extraction system. HMC estimates that approximately one pore volume has been flushed from the tailings.

Section 4.1, Flushing of Large Tailings Pile, second paragraph; Page 19. A calculation is made of the natural groundwater flow in the alluvial aquifer beneath the large tailings pile, which is substantially overestimated. Based on site data, the hydraulic conductivity of the alluvium used in the calculation should be about 20 feet/day, not 80 feet/day. The gradient of 0.008 is high and should be lower near approximately 0.003. HMC's estimate of the natural flow in the alluvial aquifer is in the range of 60 to 80 gpm, not 450 gpm as estimated by the ACOE. Consequently, the amount of alluvial groundwater that needs to be captured beneath or surrounding the large tailings pile is considerably less than what is estimated by the ACOE.

Section 4.2, Downgradient Extraction and Injection, first paragraph; Pages 19-20. The ACOE states that injection of relatively clean water from other aquifers into the alluvial aquifer may do more to dilute the plume than treat it. However, injection of water has demonstrated to be an effective technology for plume control, and in addition to controlling the plumes, injection is often necessary to sustain a sufficient saturated thickness in the alluvial aquifer to enable extraction to occur; otherwise the aquifer would be dry. An example of this is at Felice Acres, where injection into the alluvial aquifer occurs. Initial extraction wells in this area yielded very little water and wells commonly became dry when pumped. With injection, a sufficient saturated thickness is maintained that enables uranium and other constituents to be collected. Without injection little or no constituent mass would be extracted.

The ACOE also states that extraction from the Upper Chinle draws water downward from the more contaminated alluvial aquifer. The only area where this could possibly occur is in the collection pond area where there is an approximate 500-foot wide zone of saturated alluvium overlying the Upper Chinle Aquifer, and extraction in the Upper Chinle Aquifer occurs in this area. However, HMC does not believe that pumping from the Upper Chinle Aquifer in this limited area is drawing contaminants downward as the following explains. The two most important parameters that control the movement from one aquifer to another are the head in the driving aquifer and the vertical hydraulic conductivity of the materials that the water has to move through between the two aquifers. In the collection pond area, the head in the alluvial aquifer would have to be substantially higher than the head in the Upper Chinle Aquifer and the materials would have to be highly permeable. Review of the 2008 water levels in the two aquifers in this area reveals that there is minimal head difference. As shown on the water level elevation map for the alluvial aquifer (Figure 4.2-1, HMC and Hydro-Engineering, LLC. 2009), the elevation near the collection pond is typically in the range of 6,525 to 6,530 feet. Water elevation in Upper Chinle Aquifer (Figure 5.2-1, HMC and Hydro-Engineering, LLC. 2009) is also interpreted to be in the same elevation range. Water levels in the two aquifers near the collection pond have not significantly changed since the increased pumping in the Upper Chinle aquifer started in 2006, which is further evidence that the pumping has not induced downward flow from the alluvial aquifer.

Section 4.4.3, In-Situ Immobilization; page 27. The ACOE suggests that a relatively new immobilization technology, still in lab development, be examined. The reference given is to "Frysell et al., 2005." This citation is incorrect; it should be Fryxell et al., 2005 (as noted correctly in Section 10, References). The referenced work involves the use of self-assembled monolayers on mesoporous supports (SAMMS), and as indicated by the ACOE, this is experimental and currently confined to the laboratory bench.

Section 5.3, Alternatives to Current Treatment Operation; page 30. The ACOE states that ion exchange resin cannot reliably remove the cation form of selenium, selenite. Selenium will not be present as a cation in the groundwater. Selenium typically is found as selenate (SeO_4^{2-}; with selenium in the +6 oxidation state) or selinite ($HSeO_3^-$ or SeO_3^{2-}; with selenium in the +4 oxidation state) depending upon pH. All of these forms of selenium are anionic.

Section 6.2, Effect of Salinity; page 32. An evaporation rate reduction of 50 percent in the ponds is cited. However, HMC's research has found that the reduction rate is lower at approximately 10 percent (Salhotra et al. 1985) for the salinity present in the evaporation ponds.

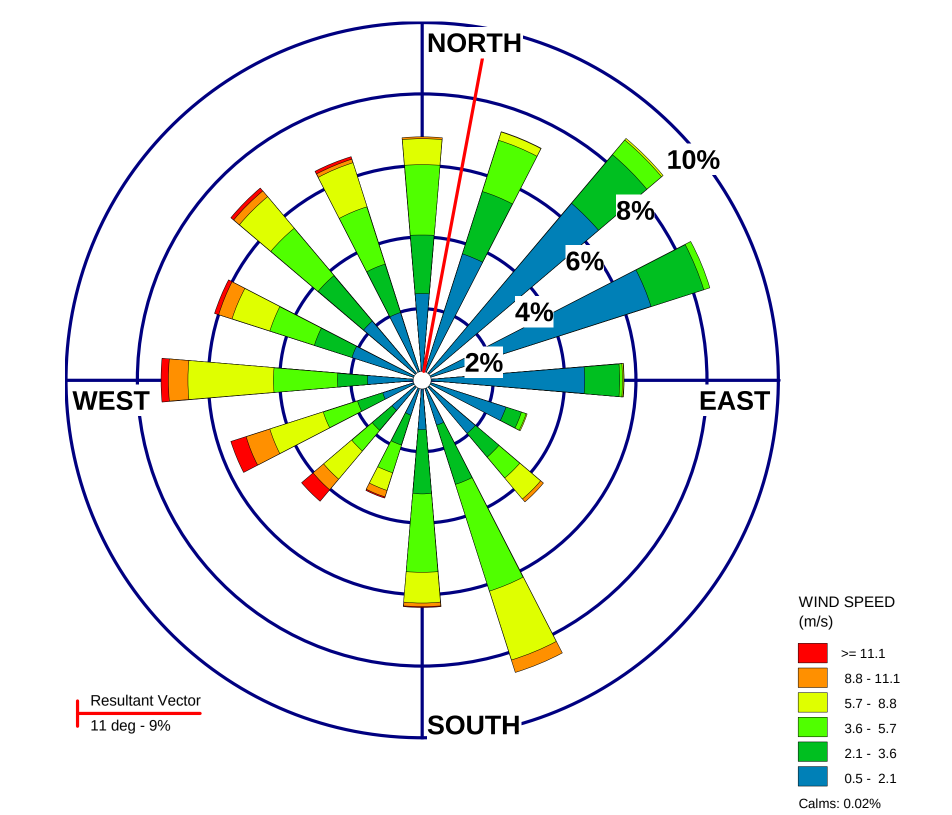
Section **7.2.4, Sampling Methodology and Analytical Suite; page 38**. The ACOE provides details of improvements to the presentation of data in the air particulate laboratory reports. HMC has followed the standard reporting format required by NRC for the laboratory reports.

Section 9.3, Approach to Implementation of Recommendations, second paragraph; page 47. The ACOE provides a list of six recommendations that should proceed independent of any other recommendations. HMC's view on each of these recommendations and how to proceed are discussed in our responses as identified below:

1) the evaluation of the potential escape of contaminants at the northwestern portion of the site (see Response to Recommendation No. 3)
2) the evaluation of the former mill site as a potential source of groundwater contamination (see Response to Recommendation No. 4)
3) further characterization of the extent and migration of the Chinle plumes (see Response to Recommendation No. 5)
4) complete decommissioning of potentially compromised San Andres wells (see Response to Recommendation No. 7)
5) development of a comprehensive optimized monitoring program (see Response to Recommendation No. 12)
6) implement treatment of contaminated irrigation water to remove contaminant mass from the environment (see Response to Recommendation No. 14)

ATTACHMENT B – Wind Rose

WIND ROSE PLOT:	DISPLAY:
Homestake Meterology Station Wind Rose	**Presented in a circular format, the wind rose shows the frequency of winds blowing from particular directions over a period of time. The length of each "spoke" around the circle is related to the frequency that the wind blows from a particular direction per unit time. Each concentric represents a different frequency, emanation from 0% at the center and increasing to 10% at the outer circle.**



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	00:00 September 1, 2008 to 23:00 August 31, 2009	MODELER:	
	CALM WINDS: **0.02%**	TOTAL COUNT: **8765 hrs.**	
	AVG. WIND SPEED: **3.49 m/s**	DATE: **9/29/2009**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

NEW MEXICO
ENVIRONMENT DEPARTMENT

Ground Water Quality Bureau

1190 St. Francis Drive, P. O. Box 5469
Santa Fe, NM 87502
Phone (505) 827-2900 Fax (505) 827-2965
www.nmenv.state.nm.us

BILL RICHARDSON
Governor
DIANE DENISH
Lieutenant Governor

RON CURRY
Secretary
SARA COTTRELL
Deputy Secretary

April 19, 2010

Ms. Kathy Yager
U.S. Environmental Protection Agency
Technology Innovation and Field Services Division
11 Technology Drive (ECA/OEME)
North Chelmsford, MA 01863

RE: Comments from the New Mexico Environment Department on DRAFT REPORT "Focused review of specific remediation issues; an addendum to the Remediation System Evaluation for the Homestake Mining Company (Grants) Superfund Site, New Mexico" (U.S. Army Corps of Engineers, February 2010)

The New Mexico Environment Department Ground Water Quality Bureau ("NMED") has reviewed the above-referenced report, and generally finds it to be a very thorough and comprehensive evaluation of the operating remedial systems operational at this Site. NMED appreciates the amount of effort reflected in this draft, and submits the following comments for consideration in the final draft:

Specific comments

Section no.	Comment
1.1.2	Assessment of the adequacy of the Site monitoring network (Bullet #5) should also include evaluation of wells to monitor the delineation between saturated and unsaturated conditions in the alluvium, with emphasis on the potential for contaminants to migrate from the southernmost alluvial contaminant plume without detection.
1.4.3	Site contaminants of concern for which ground water remedial goals have been established include nitrate, chloride, and vanadium. NMED notes that interpretation of nitrate data may be complicated by agricultural activities that occurred prior to and during legacy uranium activities in the area. The second to the last sentence in the first paragraph compares alluvial ground water data from 2.5 miles west of the site to alluvial ground water data at the site to demonstrate degradation of water quality. This is not an appropriate comparison as the alluvial ground water data taken west of the site is representative of San Jose alluvial water, whereas the data for the site is San Mateo alluvial ground water. The first sentence in the second paragraph should read "Water within the tailings piles…"
1.4.6	Note that EP-2 construction included a double liner with leak detection.
2.1.2	Another possible explanation for elevated contaminant concentrations in the "1" series wells could be the result of a concentration gradient.
2.1.3	Please qualitatively evaluate potential ecological risks from the use of uncovered evaporation and collection ponds.
2.2	Although the surface water pathway is not complete, periodic flooding due to heavy rainfall does occur. Furthermore, one conclusion in this report is that contaminant-

Section no.	Comment
	source waste materials (i.e., the tailing piles) should remain on-site. Therefore, NMED herein reiterates an earlier comment from the discussion of the scope of work for this study that review of flood control structure constructed for the long-term protection of the tailings piles must be included within the RSE.
2.2.3	Although alternative water sources (i.e., hookups to the Milan municipal water supply) have been offered to current residents within an Area of Concern, which NMED has defined based upon the surface areal extent of Site-derived historical ground water contaminant plumes, there are currently no mechanisms either to require such hookup for current or future residents, nor to preclude the use and installation of private wells within this area. Additionally, current monitoring for potential Site-derived impacts to the San Andres aquifer is inadequate to document long-term protection of this aquifer. For these reasons, NMED does not agree with the assertion that the ground water pathway is incomplete.
2.3	The last sentence should refer to Figure 2 instead of Figure 1.
3.2	Please move x-axis label to bottom of figures 3, 4, and 8.
3.6	The San Andres aquifer is an important municipal water supply source to the nearby major population centers of Grants, Milan, and Bluewater, as well as to residents using private wells within the impacted subdivisions south of the Site. NMED asserts that routine and focused monitoring of this aquifer, both upgradient and downgradient of the Site, should be included within the Remedial System to better support an assertion of no contaminant impacts to this aquifer from the overlying Site-contaminated aquifers.
4.1	The RSE team's argument for the discontinuation of the Large Tailings Pile ("LTP") flushing appears to be incomplete. NMED suggests that trends of contaminant concentrations in effluent discharged to the collection ponds should be evaluated and cited. Additionally, the heterogeneity of the LTP materials could indicate that some portion of uranium concentrations that do not respond to flushing (e.g., contaminants within slimes and other fine-grained materials) mostly will remain in-situ, and, therefore, may not significantly impact alluvial ground water quality after flushing of the more-accessible and mobile contaminant concentrations within the LTP meets the flushing effluent objective. The RSE team might consider whether 1) continued flushing with reducing and/or low-alkalinity solutions to "fix" remaining accessible contaminants in-situ, and/or 2) deployment of either an impermeable or an evaporative cover to the LTP, could reduce additional contaminant leaching from the LTP once draindown is complete. "Tailings" in Figure 15 is misspelled. The RSE team did not document evaluation of possible alternatives to flushing of the LTP. Please provide an evaluation of possible alternative actions, including a comparative analysis of pump-and-treat at the toe of the LTP during draindown, in-situ immobilization technologies, and any other applicable alternatives. The second sentence in the second paragraph on page 19 should acknowledge that draindown of the LTP may take decades. The last paragraph appears to assume a trend of decreasing contaminant concentrations after LTP flushing is discontinued. While flow rates would likely decrease over time due to termination of flushing, the RSE should address the possibility that contaminant concentrations in ground water may increase.
4.2	The last sentence of the first paragraph on page 20 recommends injection of fresh water into the Chinle to reverse the recharge (contamination) from the alluvium to the Upper Chinle. NMED recommends that the RSE team evaluate the possibility

Section no.	Comment
	that this action may exacerbate migration of contamination in the Upper Chinle.
4.3	The reliance on "existing liner (*sic*) under pond wastes" for long-term waste isolation may be inappropriate due to the observed and presumed deterioration of these mostly single liners over the ponds' usage period. Additionally, NMED recommends that the RSE team define the term "highly effective cap" within the context of long-term waste isolation. No alternative methods of evaluation were discussed to determine if ponds were leaking other than investigative methods.
4.4.1	The proposal for deployment of slurry walls does not address the long-term objective to achieve ground water protection standards through establishment of stable, self-sustaining Site conditions without ongoing maintenance requirements. NMED recommends that the RSE team attempt to quantify the length of time and associated costs for such maintenance as would be required under this proposal, in the same manner that the proposal for permeable reactive barrier emplacement is evaluated in the section following the discussion of this option in the report.
4.4.3	As noted above, the RSE team might evaluate whether in-situ immobilization technology could be appropriate to LTP flushing.
4.4.4	For consistency, the RSE team should employ similar AFCEE Sustainable Remediation Tool analysis of other proposed remedial options.
6.3	The original RSE report identified persistent operation and maintenance issues affecting the operation and maintenance of the evaporative sprayers. NMED recommends that the RSE team examine whether any different equipment and/or deployment strategies are available that could address these issues to enhance evaporation. The last paragraph states 180 gpm as the proposed flow of wastewater into the evaporation ponds for disposal. This flow assumes the LTP flushing program is discontinued, but does not account for flows from the toe drain collection wells.
7.1.1	Documentation of the protection of the San Andres aquifer from impacts derived from the overlying contaminated aquifers should be an important component of the overall monitoring strategy for the Site.
7.1.2	An important component of a critical re-evaluation of Homestake's monitoring system should be appraisal of each monitor well's completion documentation and current condition to ensure that samples from each well accurately reflect the ground water quality within the aquifer that is presumed to be monitored. Additional monitoring wells located at the confluence of the San Mateo and Rio San Jose alluvial systems to monitor the stability of ground water conditions within the alluvial aquifer should be considered.
8.1.1	The RESRAD modeling should be updated with current data which indicates contaminants have migrated in the irrigated soils well beyond 1 meter vertically.
8.2	It must be noted that the New Mexico Water Quality Control ground water standard for selenium is 0.05 mg/l, not 0.12 mg/l.

Please contact either David L. Mayerson at (505) 476-3777 or Jerry Schoeppner at (505) 827-0652 if you should need clarification on any of these comments.

Sincerely,

David L. Mayerson
Superfund Oversight Section

Jerry Schoeppner
Mining and Environmental Compliance Section

Ground Water Quality Bureau
New Mexico Environment Department

Copies:

Mr. Sairam Appaji, EPA

NMED/GWQB/SOS April 2010 read file
HMC 2010 correspondence file (SOS)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

May 10, 2010

MEMORANDUM

SUBJECT: Review of Draft Focused Review of Specific Remediation Issues, An Addendum to the Remediation System Evaluation for the Homestake Mining Company (Grants) Superfund Site, New Mexico" (February 2010)

FROM: Robert Ford, Ph.D., Research Environmental Scientist
Land Remediation and Pollution Control Division

Kathleen Yager, Environmental Engineer
Office of Superfund Remediation and Technology Innovation

Sai Appaji, Environmental Scientist
EPA Region 6, Superfund Division

TO: Mr. David Becker, Geologist
USACE EM CX

We have reviewed the draft "Focused Review of Specific Remediation Issues, An Addendum to the Remediation System Evaluation for the Homestake Mining Company (Grants) Superfund Site, New Mexico" (February 2010). Our comments are provided below.

General Comments

1. Considering the scope of work, time and budget constraints, the USACE has done a commendable job in evaluating this complex site and provided some practical recommendations.
2. The report is well written and addresses the issues at length that were important to the stakeholders.
3. The graphs in the report should be reformatted, especially the x and y axis descriptions to better illustrate the data trends.
Include additional figures wherever possible to show location of wells for better understanding of the remedial system.

Specific Comments

1. Section 3.4 Ground-Water Modeling, Pages 15-16:
I agree with concern about the modeling approach for projecting uranium (and other contaminant) concentrations in the Large Tailings Pile (LTP) water under the currently

implemented and projected flushing strategy. While the heterogeneity in the distribution of flushing efficiency throughout the LTP is a concern, assumption that there are no interactions leading to contaminant mass exchange between tailings solids and water represents an equal concern. This assumption currently drives the projection of a stable uranium concentration starting in 2012, which is the planned date for cessation of clean water injection into the LTP (see Figure 1 and detail for uranium in Figure 2). Continued injection of water into the LTP sustains and enhances the hydraulic gradient for contaminant releases into the underlying and downgradient alluvium. Exposure of tailings solids to this continuing input of water also provides the conditions for release of previously undissolved contaminants, as has been observed at other sites where uranium residuals in contaminated soils serve as a source of long-term contaminant release into groundwater [examples include: Monticello Mill Tailings Site Operable Unit III (EPA ID#UT3890090035); Hanford 300-FF-1 Operable Unit (EPA ID#WA2890090077].

In line with the recommendation to curtail the current flushing operation, I recommend implementing a pilot test prior to 2012 to examine the potential for contaminant concentration rebound as a result of the cessation of flushing. This represents a current data gap in the conceptual understanding of the ability to achieve and sustain the projected target concentration(s) for contaminants in the LTP seepage. The results from this field test can provide valuable information relative to evaluating the potential long-term performance of the current remediation strategy. Extraction and downgradient injection operations could continue as present in order to exert hydraulic control on contaminant plume(s) during the pilot study. It is recommended that a technical discussion occur between all parties involved in site restoration, management, and oversight, given the observed disparity between remedial design model projections and historical site-specific monitoring data (see Figure 2 for uranium).

2. Section 4.2 Downgradient Extraction and Injection, Page 20:

The following statement is made within the report text: “Contamination downgradient of these points would be allowed to naturally attenuate due to dispersion. Based on the presumed oxidized condition and low organic carbon content of the alluvial aquifer, other attenuation processes are unlikely to be significant.” With regard to aquifer solids, clays and oxyhydroxide minerals are commonly the primary solid components to which metals and radionuclides will partition within the alluvium. Existing information on sorption characteristics of the impacted alluvium may be available through analysis of information presented in ATTACHMENT A - ALLUVIAL AQUIFER RETARDATION AND DISPERSION TEST RESULTS (GROUND-WATER MODELING FOR HOMESTAKE’S GRANTS PROJECT, Hydro-Engineering, L.L.C., April 2006).

3. Section 7.1.4 Sampling Methodology and Analytical Suite:

I recommend caution with regard to the suggestion of “no-purge sampling” as an option for metals/radionuclides sampling from the HMC network of wells. If this recommendation is pursued, I recommend that a comparison of analytical data first be conducted for a subset of site wells prior to switching to this type of a sampling device.

Purging or pumping from the well screen is applied to help insure that the water being sampled is from the surrounding formation versus storage within the well casing. The comparability between purge and no-purge sampling techniques will depend on the degree to which formation water naturally exchanges through the well screen/casing. One specific problem

I would anticipate for collection of metals/radionuclides samples is the accumulation of mineral precipitates within the well casing that may be dislodged and entrained within the sampler. For example, this is a common problem for well screens completed in aquifers with high ferrous iron concentrations and periodic intrusions of oxygen either from water table fluctuations or gas exchange from air in the well casing. One diagnostic to determine if this condition exists for well screens at the HMC Site is to periodically pull up and examine dedicated sampling devices, e.g., flexible polyethylene/teflon tubing or in -well pumps. If there are precipitate coatings on the device at the depth of the well screen, then I would be cautious about using a no-purge sampling device. These coatings are a common source of elevated turbidity at the initiation of low -flow, low-stress sampling, but these newly suspended solids are quickly eliminated near the beginning of the purging process as they are flushed from the well casing. These coatings are also strong sorbents for many of the TAL metals and can bias analytical data, especially for unfiltered samples.

The most comprehensive source of information on the benefits and limitations of these sampling approaches is posted at the Interstate Technology and Regulatory Council website: http://www.itrcweb.org/guidancedocument.asp?TID=12. (Look at documents DSP-4 and DSP-5; note that the Snap Sampler collects a grab sample versus relying on diffusion across a membrane.)

Figure 1. Time trend in average groundwater constituent concentrations for LTP seepage ("Tails" and "Toe" data in Table 2.1-1; 2009 ANNUAL MONITORING REPORT / PERFORMANCE REVIEW, March 2010), alluvial groundwater ("G.W." in Table 2.1-1), and projection of restoration performance for LTP injection-collection system (Seepage Model, "Reformulated Mixing Model Flushing Case F"). Tailings seepage model uranium concentration projection is documented in GROUND-WATER MODELING FOR HOMESTAKE'S GRANTS PROJECT, Hydro-Engineering, L.L.C., April 2006 (Table 1-4); proposed cessation of water injection in LTP provided on page ES-3 of cited report.

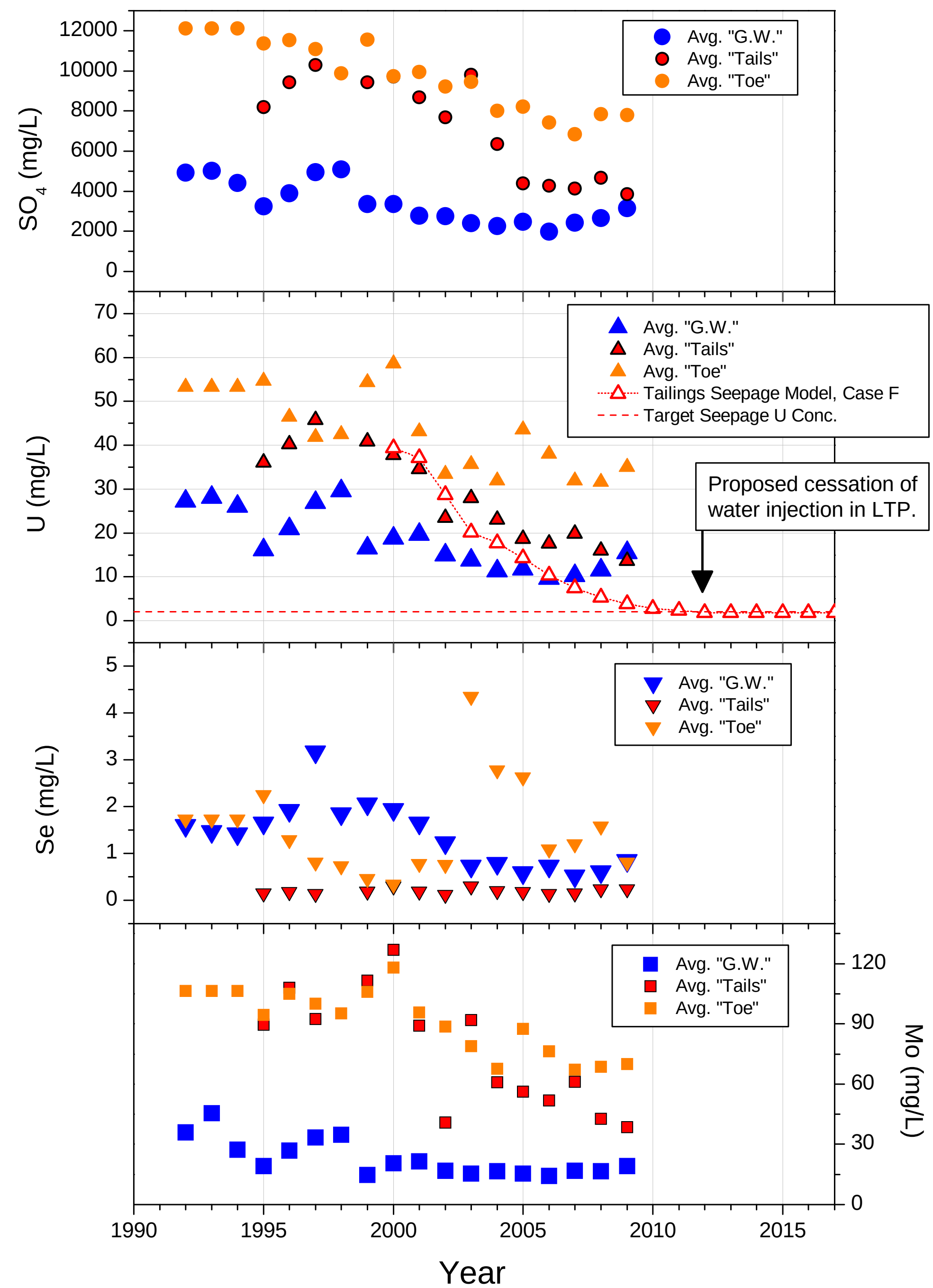
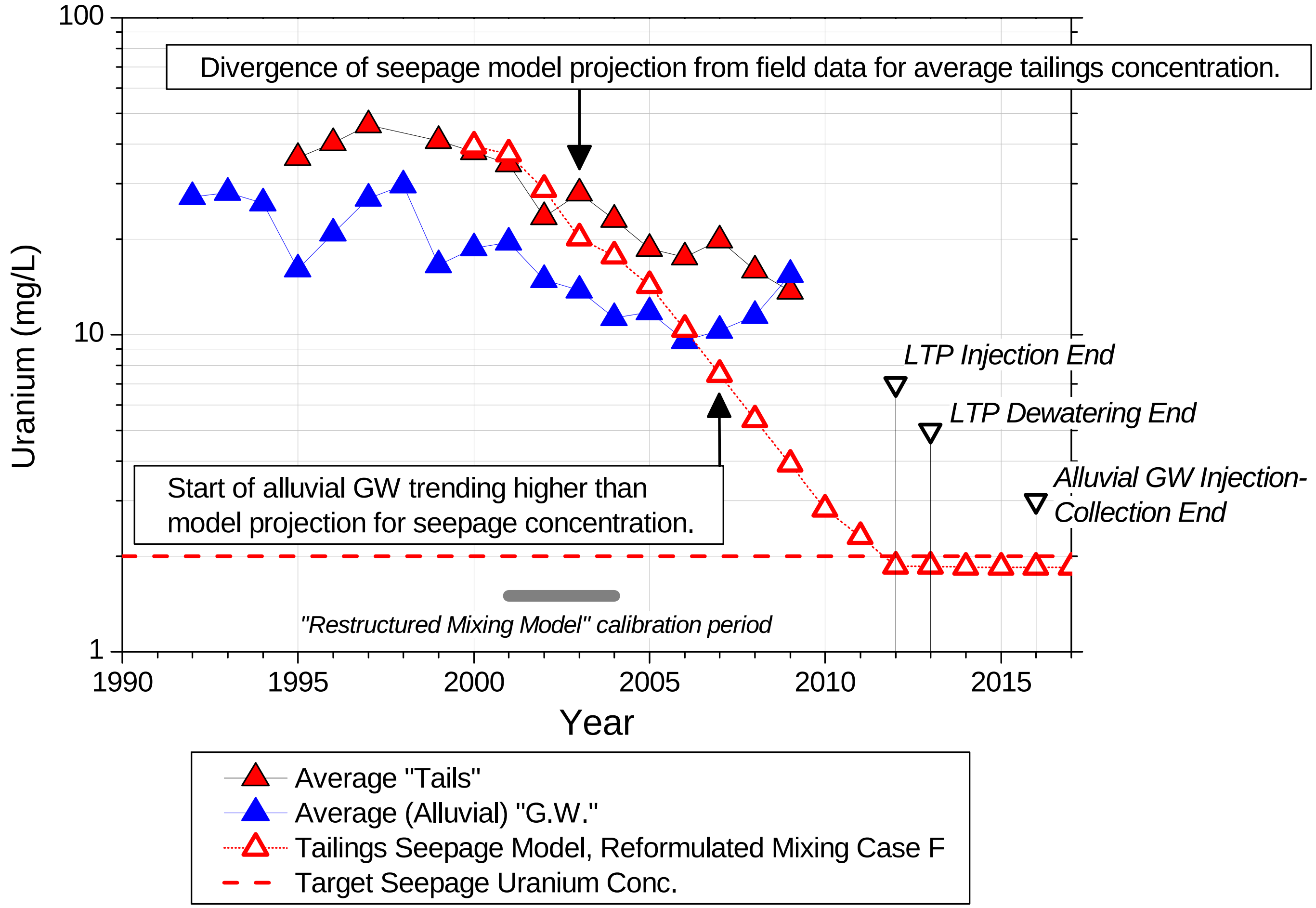


Figure 2. Years 1992-2009 time trend in average uranium concentration for LTP seepage (Table 2.1-1, 2009 ANNUAL MONITORING REPORT / PERFORMANCE REVIEW, March 2010), alluvial groundwater (Table 2.1-1), and projection of restoration performance for LTP injection-collection system (Seepage Model, "Reformulated Mixing Model Flushing Case F"). Tailings seepage model uranium concentration projection is documented in GROUND-WATER MODELING FOR HOMESTAKE'S GRANTS PROJECT, Hydro-Engineering, L.L.C., April 2006 (Table 1-4); projected times [labeled with open, black triangles (▽)] for cessation of LTP injection, LTP dewatering, and alluvial groundwater injection-collection provided on page ES-3 of cited report.



4. page i through iv. Be consistent with the use of periods at the end of bulleted sentences/phases. Some sentences/phases have periods while other do not

5. page i, first bullet. Add "with the current remedial strategy" to the end of the sentence

6. page I, 3rd paragraph, sentence beginning with "The analysis…". Change "**at** the USACE EM CX" to "**by** the USACE EM CX".

7. pages v through vii. Be sure to align page numbers to the right. Currently numbers are scattered across pages.

8. page 2., Substitute "Robert Ford" for "Michele Simon". Michelle is no longer involved in the project.

9. page 7, section 2.2.1, first sentence. Change 'human' to humans"

10. page 7, section 2.2.2, first sentence. Change 'and' to 'can'.

11. page 9, Figure 1. Add a figure that clearly indicates monitoring well locations. I can not identify monitoring wells referenced in the report on this figure.

12. page 11 Figures, and Figure throughout document. Please check the labels on the x and y axes – the dates and other units are not correctly located or easy to read. Please reformat figures to allow for accurate reading of the x and y values.

13. page 17, last paragraph, 3rd sentence. Change 'has' to 'have' and change figure to "Figure 15 in the same sentence.

14. page 18,. paragraph in the middle of the page regarding additional testing of oxidation-reduction potential. Please elaborate on the types of add'l testing that would be necessary and how the data should be interpreted.

15. page 19, 2nd paragraph. Please clarify the "average saturated thickness" mentioned regarding the calculation of natural flow. Please include the thickness of the various aquifers at least by reference.

16. page 20, 2nd paragraph. Please add information regarding how the boundary for active pumping vs. natural attenuation should be determined. Please discuss the need to use modeling or other lines of evidence to help quantify this boundary. Currently, the statement regarding use of the current extraction wells as the cut off point between capture and natural attenuation seems arbitrary.

17. page 20, 3rd paragraph. Please elaborate on the types of additional study required to assess unusual water levels.

18. page 21, 1st paragraph. Has it been confirmed that the 100 foot error in the C series wells is in fact in error or are you assuming that it is an error?

19. page 23, 1st paragraph. Double periods at the end of the paragraph.

20. page 23, 2nd paragraph. Double periods at the end of the first sentence.

21. page 23, Table 1. Please create table with gridlines and align numerical values left or right. Currently I believe they are centered and it is awkward to read. – same goes for Table 2 on page 25.

22. page 23. In the recommendation on slurry wall construction, USACE should consider deleting the last sentence "The decision for implementing such an alternative would depend on the economics of the situation" or adding additional clarification. It is not clear why only this alternative would depend on the economics and not the others.

23. page 27, regarding the recommendation of relocation of the tailings the USACE should consider evaluating additional potential hazards from moving the tailings pile besides the CO2 emissions and fatalities. Are there other practical risks from moving the pile?

<u>Other</u>

Please update the last statement on page 5 regarding the approval of the new evaporation pond on the north side of the LTP. NMED has recently approved the discharge permit for the new evaporation pond.

NRC Comments on Draft RSE Report

General Comment

The scope of work states, "In general, the review is intended to provide a critical review of the current remedial ground water strategy, including whether other approaches or technologies could be incorporated that may be more efficient and/or effective at achieving site closure goals. The outcome will be a summary of any recommended modifications necessary to improve performance or overcome performance deficiencies, or that would potentially reduce life-cycle costs or time to achievement of remedial goals."

In general, the draft report appears not to provide a strong basis for decision-making because of limitations in the analysis and because it does not compare current remediation strategies to those that are recommended. As a result it lacks the information necessary to show how the revised strategy will be more efficient and/or effective at achieving site closure goals.

Specific Comments

1. Technical conclusions made in the report are routinely qualified with "may be", "it appears", or "likely" which detracts from the usefulness of the document because it introduces uncertainty about the effectiveness of the proposed remedies due to a lack of data, or a lack of time to fully assess the hydrologic system. Pursuing changes to the current remedial strategy with this level of uncertainty seems unwarranted. Specific comments supporting this conclusion are provided below.

   a. Section 2 - Conceptual Site Model

      Section 2.1.2 identifies the location of the former mill buildings as a potential source of contamination to the ground water. However, there is very little basis provided for such a conclusion. This section states there is "**some suggestion**" in ground water monitoring data for this conclusion. It goes on to say that the elevated uranium levels in the 1 series wells have been observed but that the "**nature of the source is unclear**."

   b. Section 3.1 – Hydraulic Capture

      Section 3.1 states, "Capture **is not apparent** for the irrigation pumping in the downgradient portions of the uranium and selenium plumes, **nor is it clear from available data** that capture of the plume along Highway 605 east of the site is maintained." Based on this statement, the reviewers should not draw any conclusion about the adequacy of plume capture.

   c. Section 3.4 – Ground-Water Modeling

      The report states, "The primary concern with the modeling conducted for the site is the simulation of the seepage of contaminated water from the large tailings pile. **From the available information** on this step in the modeling process, **it**

Enclosure

appears the modeling did not account for the **likely heterogeneity** and preferred pathways for water injected into the tailings. **It seems likely** that the flux of water is not uniform through the pile and that large volumes of the pile still have a significant amount of their original pore fluids. **The model likely over-predicts** the performance of tailings flushing."

d. Section 4.1 – Flushing of large Tailings Pile

- "..heterogeneity of the materials **has likely** prevented.."
- "..**makes it difficult** to assess.."
- "**It is not obvious** the flushing program would meets its goal by 2012.."

e. Section 4.4.1 – Slurry Wall

"This would **potentially reduce** the long-term costs for the operations, **possibly significantly.**"

f. Section 7.1.4 - Sampling Methodology

"The use of no-purge sampling techniques, such as Hydrasleeves and Snap samplers **may be considered to reduce** the time necessary to sample the wells." The use of no-purge sampling was not determined to be a time saving or cost savings alternative to the current sampling methodology utilized by Homestake.

g. Section 7.2.2 – Monitoring Network

"The number and location of control monitoring stations **may not be adequate** to meet the overall objective of ensuring compliance with the public dose limit in 10 CFR 20.1301."

Given that the NRC staff has previously determined that the number and location of control monitoring stations is adequate, the reviewer should provide additional justification for its statement.

2. Section 4.2 Downgradient Extraction and Injection

The NRC staff does not agree with the statement, "…injection of relatively clean water from other aquifers into the alluvial aquifer downgradient of the site at rates that exceed extraction complicates the control of the plumes and may do more to dilute the plume rather than treat it." We believe injection is necessary because the hydraulic control cannot be maintained in the unconfined alluvial aquifer by extraction alone. The number of extraction wells and their pumping rates would have to be increased to maintain hydraulic control to an area of this size.

USACE should re-evaluate the recommendations in this section.

3. Section 7.1.5 - Further Optimization Opportunities

Optimization tools mentioned in this section should have been used for this evaluation for a limited data set, at minimum, to provide a basis for recommended changes to the groundwater and air monitoring programs.

4. Section 7.2.2, refers to the "large area potentially impacted by the Homestake effluent releases". The report should specify what area is impacted by the Homestake tailing piles radon releases. The Shearer and Sill surveys (Health Physics, 17 (1), pp. 77-88) of radon-222 concentrations in the vicinity of uranium mill tailing piles, appear to conclude that no statistically significant difference between measured radon-222 concentrations around tailing piles and background radon-222 levels could be discerned beyond a mile from the tailing piles.

   The methods in US NRC Regulatory Guide 8.30 for radon-222 daughter measurements are better suited for assessment of worker's exposure to radon daughters indoors, and most of these methods may not be appropriate for determining either outdoor radon progeny levels or an equilibrium factor. The determination of a radon background level and an appropriate radon & radon progeny equilibrium factor are especially important and challenging to determine.

5. Section 8.0 - Although efforts were made to take a conservative approach to modeling this site, RESRAD was not designed to be used to evaluate doses from contaminated irrigation water. There are other computer codes (e.g., GENII) that can be used to evaluate doses associated with irrigation. Other options, such as the Radium Benchmark Dose, which is discussed in 40 CFR 192 and 10 CFR 40, Appendix A, Criterion 6(6) could also be used.

   Some RESRAD parameter values may impact the dose received by the future resident such as the use of 400 acres (1.6E+6 m^2) of soil irrigated with contaminated irrigation water. It is unlikely that a single individual would be exposed to the entire area while living on the site. Consideration of soil dilution associated with the construction of a house with a basement can further decrease the amount of contaminated soil a future resident may be exposed while the increase in time spent outside from 25% to 50% of the future resident's time may increase the dose. When evaluating the dose to a future resident it is also important to include all relevant exposure pathways (e.g., external exposure, inhalation, ingestion, and radon) associated with the site.

6. Section 8.2.1 - There is no basis for applying the New Mexico water quality standards for irrigation water. Removal of contaminants prior to irrigation would defeat the purpose of this remediation strategy. In addition, this section implies that the current practice of directly applying untreated extracted groundwater for irrigation is done with effluent concentrations above discharge standards. Groundwater used for irrigation has been below the discharge standards required by Homestake's license, which is based on 10 CFR 20, Appendix B, Table 2 values.

7. Section 8.2.2 indicates that uranium leaching into groundwater is not considered to be a likely risk. If the risk is small, and Homestake is meeting its regulatory requirements,

how will the suggestions offered to reduce uranium mobility in the irrigated soil make the current decommissioning strategy more efficient and/or effective at achieving site closure goals?

8. Section 9 - Summary of Conclusions and Recommendations

Bullet number 1 of Section 9.1 states that ground water remediation is very unlikely to be achieved by 2017. The basis for this statement is unclear since the RSE addendum did not determine an estimated remediation date for the current remediation strategy nor did it provide an estimated remediation date for the implementation of the recommended changes.

OBSERVATIONS AND RECOMMENDATIONS REGARDING THE DRAFT FOCUSED REVIEW OF SPECIFIC REMEDIATION ISSUES FOR THE HOMESTAKE MINING COMPANY (GRANTS) SUPERFUND SITE, February 2010

GROUNDWATER CONSIDERATIONS

Prepared by Milton Head
Member, Bluewater Valley Downstream Alliance
May 11, 2010

A. Stop flushing the Large Tailings Pile.
B. The injection and collection system is extracting a very very small part of the total contaminants. From 1977 to 1990 data shows there was no extraction of contaminants. The water collected was returned to the Large Tailings Pile. Since 1990 to 2010, approximately 210 gpm of contaminated water is being collected and stored apparently into one of the three evaporation ponds. The contaminants are being diluted not extracted. If Homestake/BG is allowed to drill the 39 new wells, they will be pumping 3,642 gpm while only 210 gpm is being treated, then only .0577% of water pumped out of the ground is being treated by extraction. This current method of remediation of H/BG site and surrounding area will cause a 4,500 to 8,000 acres tailings pile to the created.
C. There must be monitor wells drilled below the original mill site and water tested.
D. Middle Chinle - Based on data from February 2, 1960 to May 1978, of 73 monitoring points, 32 have tds data. The average tds was 1149. (See Milton Head Exhibit I attached).
E. Use USGS resistivity flights to identify all aquifers. (See Milton Head Exhibit II attached).
F. There is data on San Andres wells. History of San Andres shows many San Andres wells are showing increase in tds and uranium. (See Milton Head Exhibit III attached).
G. There is data available concerning upgradient water. There was testing done as early as 1962.(See Milton Head Exhibit IV attached).
H. Construct EP3 and put anything left over from RO extraction into EP3. The addition of EP3 should eliminate the need for spraying contaminants into the air and spreading them around the area.
I. There should be no expansion of small tailings pond near the existing STP. Put EP3 into operation.
J. A slurry wall can be used to isolate the LTP and STP. The technology is available. There would have to be a study to include concept, engineering, feasibility and cost. This does not preclude the need to move the LTP and STP. These piles can be moved through a slurry pipe, dried down and placed in a shale or clay geological formation with no risk to community or public. Moving the tailings piles is no more of a threat to the public health than any operating

uranium mill tailings. The only hindrance is the decision to move them and the money needed. However, slurrying the pile to safe permanent storage minimizes the potential for pollution as a result of the move and risk to workers.

K. Develop a comprehensive, regular and objectives-based monitoring program.

L. Allow irrigation rather than injection wells. This will allow observation of the success of extraction methods.

M. H/BG quotes large number of pounds of uranium and other constituents being removed from the ground waters - locate and identify these constituents. There should be a regular semi-annual analysis of the water and solids in the existing evaporative ponds.

Well X- dilution is not clean up so quit playing games with Well X.

Leaving uranium in an unlined tailings pile with as much water as the LTP has means it will continue to seep into our water forever even with a cover.

ANACONDA Copper Company
New Mexico Operations
P.O. Box 638
Grants, New Mexico 87020
505/876-2211

Middle Chinle Exhibit-11

October 5, 1981

Mr. John Morrow
4201 San Mateo Road
Grants, New Mexico 87020

Dear John:

Here is all the data we have on your domestic water well. We started sampling there in February, 1960, and discontinued sampling in May, 1978. I understand that the New Mexico EID has more recent sample data. You may wish to check with them.

Sincerely,

Elrod C. Leany

Elrod C. Leany,
ENVIRONMENTAL ADVISOR

jls

cc: DLR
File

Middle Chinle
Murray Acres
LOT-1, Blk-4,

Middle Chinle
Murray Acres

Middle Chinle Exhibit-1

THE ANACONDA COMPANY
WATER ANALYSIS

Murray #1 12.10.34.224

DATE		ANALYST	Cl ppm	SO_4 ppm	NO_3 ppm	pH	Cond. ppm	HCO_3 ppm	CO_3 ppm	Na ppm	Mg ppm	Ca ppm	Mn ppm	Fe ppm	TDS ppm
Nov	1969	Anaconda	39	581	1	8.6	1800	255	10	390					
Jan	1970	"	40	562	1	8.7	2000	263	10	370					
March	1970	"	39	585	1	8.5	2000	227	25	410					
May	1970	"	41	572	2	8.8	1700	225	14	390	4	6	<0.1	0.35	107
July	1970	"	38	586	2	8.8	1650	259	15	390					
Sept	1970	"	38	574	1	8.8	1400	247	20	430	3	4	<0.1	<0.1	133
Nov	1970	"	41	578	2	8.8	1350	251	15	445					
May	1971	"	42	590	1	8.7	1150	267	13	410	3	7	0.10	0.30	1,10
May	1972	"	44	550	1	8.8	1700	253	14	400	2	8	<.1	0.50	116
May	1973	"	44	574	2	8.6	1650	254	15	420	13	4	<0.1	1.00	116
MAY	1974	"	41	600	3	8.5	1800	265	4	400	1	5	<0.1	0.70	117
1975 MAY	1975	"	44	586	3	8.7	1550	210	NIL	450	1	4	<0.1	1.0	119
* May	1976	"	40	572	3	8.0	1650	300	Nil	470	<1	2	<0.1	0.9	121
May	1977		40	628	4	8.8	1700	278	25	460	8	9	<0.1	0.8	162
May	1978		40	629	<1	8.86	2100	244	24	440	1	2	<0.1	<0.1	11

Discontinued sampling

73 Total well points

(15)

12,180
11,080
12,500
35,760
32

TDS 11,149 Avg

10 121

[illegible]

WATER ANALYSIS

Murray #1 12.10.34.224

DATE		ANALYST		Cl ppm	SO_4 ppm	NO_3 ppm	pH	Cond. ppm	HCO_3 ppm	CO_3 ppm	Na ppm	K ppm	Ca ppm	Mn ppm	Fe ppm	[illegible] ppm
Jan	1965	Anaconda		39	547	<1	8.7	1800	260	16	420					
Mar	1965	"		38	542	<1	8.6	1800	255	17	400					
May	1965	"		40	549	1	8.5	1800	278	10	370	1	4	0.10	0.50	1103
July	1965	"		37	553	2	8.6	1850	256	12	370					
Sept	1965	"		41	562	2	8.7	1900	248	15	370	1	6	<0.10	0.60	1123
Nov	1965	"		38	564	<1	8.5	1900	265	10	385					
Jan	1966	"		40	551	1	8.8	1850	232	17	400					
Mar	1966	"		39	530	2	8.6	1850	247	13	385					
May	1966	"		37	551	3	8.3	1800	267	Nil	400	2	4	<0.10	0.20	1157
July	1966	"		37	553	2	8.5	1700	270	9	370					
Sept	1966	"		39	546	4	8.2	1800	255	Nil	355	1	4	<0.10	0.15	1143
Nov	1966	"		40	560	1	8.3	1900	250	Nil	370					
Jan	1967	"		39	568	1	8.5	1850	243	15	355					
March	1967	"		36	570	2	8.7	1850	225	17	370					
May	1967	"		39	567	2	8.7	1800	269	16	420	5	10	<0.10	2.0	1098
July	1967	"		39	549	3	8.7	1800	270	14	465					
Sept	1967	"		37	558	3	8.6	1800	265	16	420	1	14	<0.10	1.20	1031
Nov	1967	"		38	567	3	8.8	1750	277	17	385					
Jan	1968	"		40	524	3	8.6	1850	263	12	325					
March	1968	"		42	499	1	8.6	1900	261	12	450					
May	1968	"		43	556	1	8.9	1900	239	19	355	7	16	<0.10	0.15	1031
July	1968	"		42	562	3	8.8	1850	259	17	420					
Sept	1968	"		39	579	3	8.6	2000	248	19	376	4	6	<0.10	0.25	1134
Nov	1968	"		41	561	<1	8.8	2000	271	14	370					
Jan	1969	"		39	562	1	8.6	1800	271	9	350					
March	1969	"		43	570	<1	8.1	1900	369	Nil	390					
May	1969	"		40	566	1	8.5	1850	262	6	370	6	9	<0.1	0.30	1130
July	1969	"	(69)	50	573	1	8.7	1850	243	14	400					
Sept	1969	"		38	576	1	8.6	1700	268		390	2	6	1	0.55	1126

1108

THE ANACONDA COMPANY
WATER ANALYSIS

Murray #1 12.10.34.224

DATE	ANALYST	CL ppm	SO4 ppm	NO3 ppm	pH	Cond. umhos	HCO3 ppm	CO3 ppm	Na ppm	Mg ppm	Ca ppm	Mn ppm	Fe ppm	TDS ppm
Feb. 1960	Anaconda	48	537	1	8.6	1900	310	2	391					1153
May 1960	"	50	516	< 1	8.7	1640	300	13	400	1	4	< 0.1	0.50	1123
July 1960	"	38	526	1	8.6	1650	314	13	355					
Sept. 1960	"	38	511	2	8.5	1650	299	8	390	1	5	< 0.1	< 0.1	1097
Nov. 1960	"	38	514	< 1	8.6	1700	285	13	370					
Jan. 1961	Anaconda	37	511	2	8.7	1500	296	22	350					
Mar. 1961	"	37	516	< 1	8.7	1600	292	18	370					
May 1961	"	39	523	1	8.6	1750	272	14	350	1	6	< 0.1	< 0.1	1101
July 1961	"	38	522	2	8.6	1700	282	13	370	0.1	5.1	< 0.1	0.19	1117
Sept 1961	"	40	514	< 1	8.6	1800	275	14	340	5	8	< 0.1	0.50	1128
Nov. 1961	"	38	514	< 1	8.6	1600	291	13	340					
Jan 1962	"	81	531	<1	7.3	1900	223	NIL	370					
Mar. 1962	"	38	519	2	8.5	1700	273	13	380					
May 1962	"	37	544	2	8.6	1900	281	12	380	1	4	0.10	0.15	1221
July 1962	"	36	525	2	8.6	1750	258	16	320					
Sept 1962	"	58	530	<1	7.6	1800	271	NIL	370	1	3	<0.10	<0.10	1107
Nov 1962	"	44	535	1	8.3	1600	294	NIL	320					
Jan 1963	"	39	533	1	8.3	1800	301	NIL	350					
March 1963	"	37	541	1	8.6	1900	268	16	400					
May 1963	"	37	552	1	7.5	1750	303	NIL	390	3	8	<0.10	0.25	1066
July 1963	"	40	549	1	8.7	1800	279	14	400					
Sept 1963	"	39	552	1	8.6	1900	267	12	385	2	2	<0.10	0.30	1117
Nov 1963	"	41	535	1	8.8	1800	283	19	400					
Jan 1964	"	39	531	<1	8.7	1750	264	17	400					
March 1964	"	38	552	1	8.7	1700	260	16	400					
May 1964	"	38	536	3	8.6	1850	261	16	370	1	5	<0.10	<0.20	1119
July 1964	"	39	541	1	8.7	1900	269	15	340					
Sept 1964	"	39	527	1	8.6	1900	257	26	385	4	5	<0.10	0.20	1149
Nov 1964	"	37	63	1	8.6	1750	249	10	[illegible]					

jonnie

From: "Wade Kress" <wkress@usgs.gov>
To: "Jonnie Head" <jonnie@jonniehead.com>; "Nathan C Myers" <nmyers@usgs.gov>; "Sarah E Falk" <sefalk@usgs.gov>; "Rodger F Ferreira" <ferreira@usgs.gov>; "Douglas P McAda" <dpmcada@usgs.gov>; <Appaji.Sairam@epamail.epa.gov>; "Jared Abraham" <jdabraha@usgs.gov>; "Bruce D Smith" <bsmith@usgs.gov>; "James C Cannia" <jcannia@usgs.gov>
Sent: Monday, May 04, 2009 2:52 PM
Attach: Homestake_figures.docx
Subject: Figures used to determine APPROXIMATE location for flight lines.

Milton,

Several USGS personnel reviewed the area that was delineated last week during our conference call. To conduct a hydrogeologic framework investigation in the delineated area the project would need to be funded at about 1.5 million dollars. Please keep in mind that this is an estimate and cost is largely driven by cost to fly the survey. This cost can and does fluctuate depending on fuel costs. Please let me know if you have any questions. I have attached a few figures showing regional topography and magnetic data and the approximate flight design.

Wade H. Kress
Supervisory Hydrologist
Texas Water Science Center
West Texas Program Office
U.S. Geological Survey, WRD
944 Arroyo Drive
San Angelo, Tx 76903-9345
325-944-4600 Office
325-280-1351 Cell

M. Head
Exhibit-2

Page-1

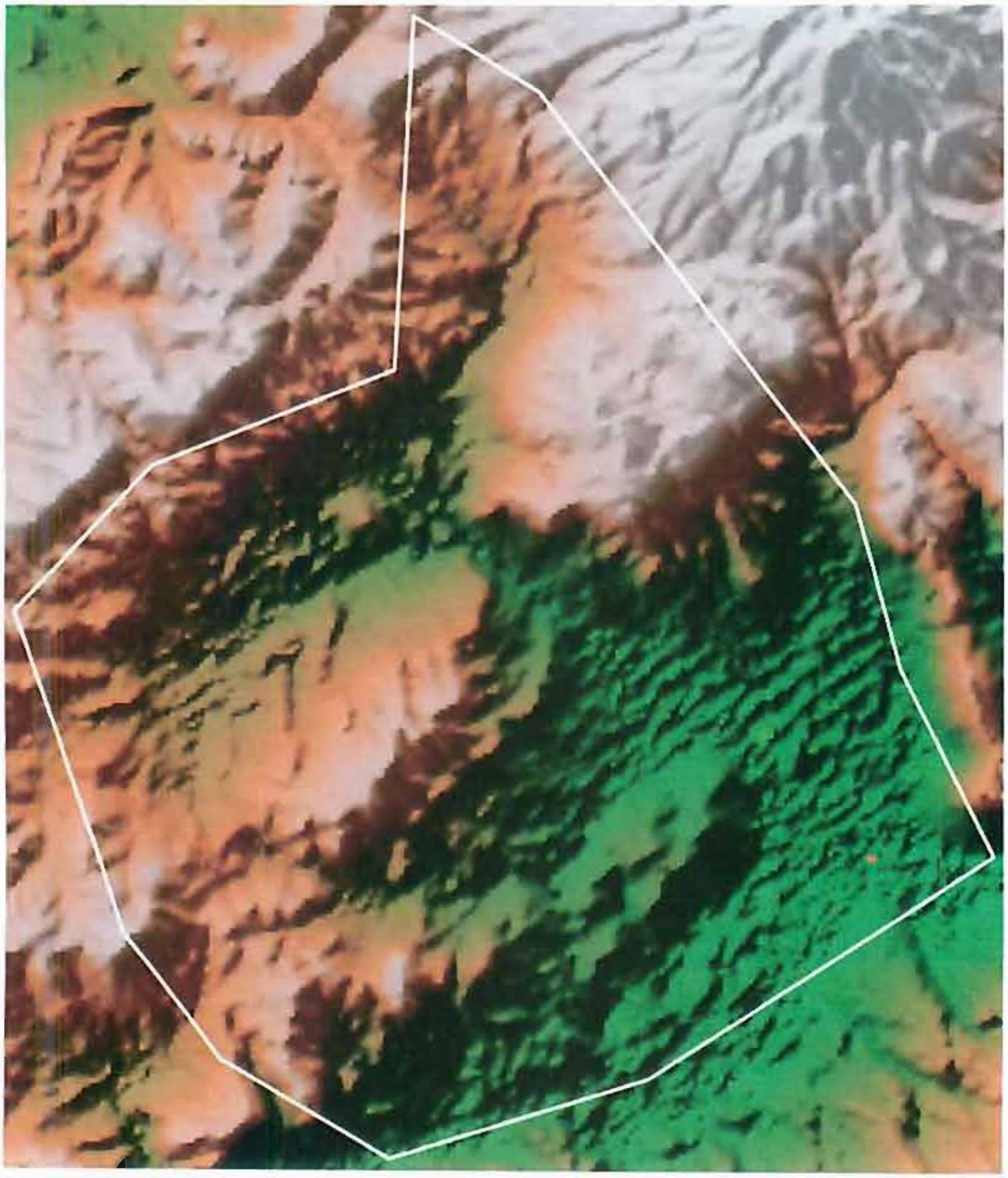


Figure 1. Map showing topography of area selected for airborne surveys.

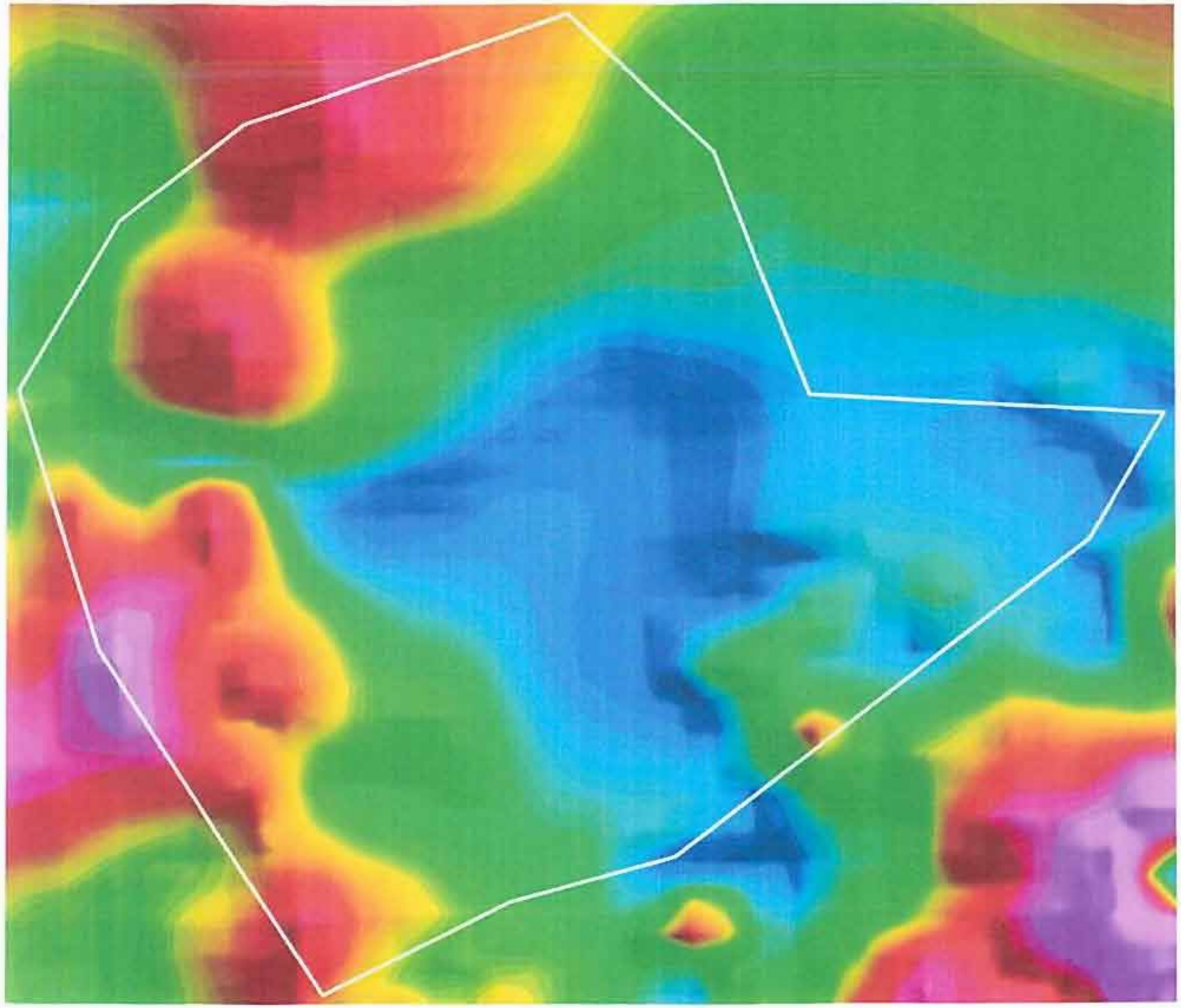


Figure 2. Map showing regional magnetic data of area selected for airborne surveys.

Page-3

Page - 4

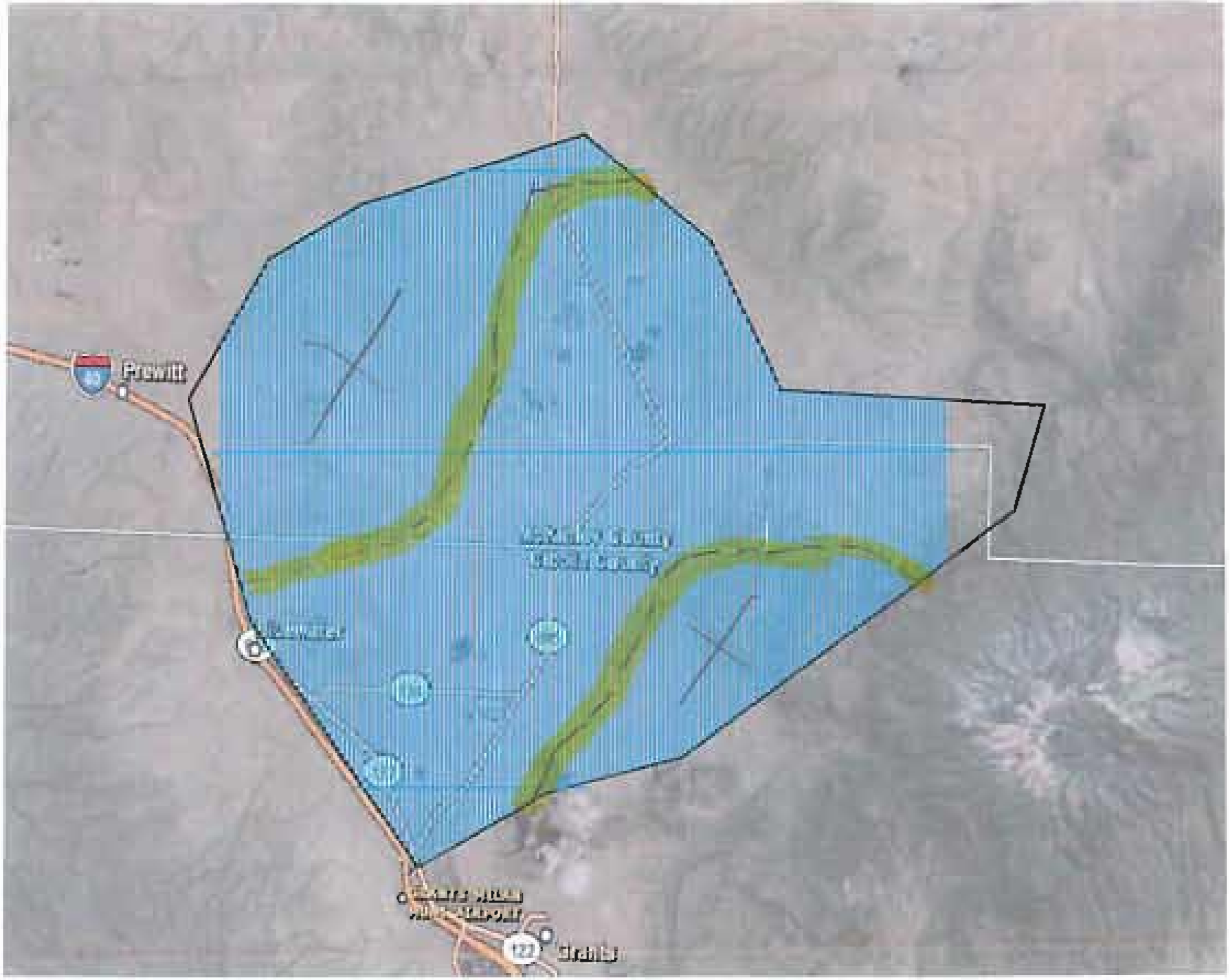


Figure 3. Map showing conceptual flight path with tie lines for airborne EM and Magnetic surveys. Approximately 3,300 line kilometers (2050 miles).

Dash Lines could be shortened at NW & S.E. Areas by Too 1353 Miles

MINERALS
ANACONDA ~~Copper~~ Company
New Mexico Operations
P.O. Box 638
Grants, New Mexico 87020
505/876-2211

San Andreas Exhibit-3
Page 1 — 34

March 15, 1982

Milton Head
P.O. Box 2011
Milan, NM 87021

RE: Water Chemistry Analysis of Murray Irrigation Well

Dear Milton:

The Anaconda Minerals Company, Environmental Staff is enclosing, per your request, the water chemistry analysis results for Murray Irrigation Well. The information provided is all that could be found on the Well.

As far as your request on the H.D. Chapman well; no information or results could be found in our files pertaining to that well or to a well listed in your name. Someone else must have been conducting the samplings;it was not Anaconda.

We hope this information fulfills your request of last week. If not, don't hesitate to call us.

Sincerely,

Carl D. Woolfolk

Carl D. Woolfolk
Sr. Env. Eng.

cc: DLR
File

THE ANACONDA COMPANY
WATER ANALYSIS

MURRAY 12.10.27.431

DATE	ANALYST	Cl ppm	SO_4 ppm	NO_3 ppm	Na ppm	Cond unhos	pH	HCO_3 ppm	CO_3 ppm	Ca ppm	Mg ppm	Fe ppm	Mn ppm	TDS ppm
MAY 1974	ANACONDA	102	502	15	160	1660	7.7	398	NIL	176	54	0.10	<0.1	1340
AUG. 1974	NO SAMPLE								/					
NOV. 1974	NO SAMPLE													
FEB. 1975	NO SAMPLE													
MAY 1975	ANACONDA	106	521	11	190	1500	7.5	367	NIL	176	55	<0.1	<0.1	1356
AUG 1975	"	103	535	14		1625	7.3	361		178	61			
NOV. 1975	NO SAMPLE													
FEB. 1976	NO SAMPLE													
May 1976	Anaconda	104	530	12	180	1600	7.5	408		176	58	0.6	<0.1	1369
Aug 1976	No sample													
Nov 1976	No sample													
Feb 1977	No sample													
May 1977		105	574	14	210	1675	7.7	400	—	175	50	<0.1	<0.1	1370
Aug. 1977		116	499	13	221	1500	7.2	425	nil	185	54			
Nov. 1977	No Sample													
Feb. 1978	No Sample												Data 29 Total	1175
May 1978	No Sample													Average
Aug 1978		109	563	14	155	2000	7.42	398	nil	190	60			
									(H)	1974-1978	Average		= TDS	1359

THE ANACONDA COMPANY
WATER ANALYSIS

Murray 12.10.27.431 1

DATE	ANALYST		Cl ppm	SO_4 ppm	NO_3 ppm	pH	Cond. ppm	HCO_3 ppm	CO_3 ppm	Na ppm	Mg ppm	Ca ppm	Mn ppm	Fe ppm	TDS ppm
Jan. 1969			No	Sample											
March 1969			No	Sample											
May 1969	Anaconda		88	485	12	7.2	1700	383	Nil	150	40	196	<0.1	<0.1	121
July 1969	"		87	467	16	7.3	1500	416	Nil	150					
Sept 1969			No Sample												
Nov 1969			No Sample												
Jan 1970			No Sample												
Mar 1970			No Sample												
May 1970	Anaconda		90	464	11	7.7	1550	338	N.I	230	38	269	<0.1	0.20	191
July 1970			No Sample												
Sept 1970	Anaconda		97	476	13	7.7	1200	420	N.I	170	55	173	<0.1	<0.1	129
Nov 1970			No Sample												
Feb 1971			No Sample												
May 1971	Anaconda		92	452	15	7.3	1200	407	N.I	180	57	172	0.10	0.38	126
Aug 1971	"		101	458	8	7.3	1750	422	N.I	170	37	139			
Nov 1971	No Sample														
Feb 1972			No	Sample											
May 1972	Anaconda		100	495	9	7.4	1600	415	N.I	160	52	171	<0.10	0.10	128
Aug 1972	"		108	475	14	7.2	1600	427	Nil	185	54	174			
Nov 1972	"		No Sample												
Feb 1972	"		No Sample												
May 1972	"		100	495	9	7.4	1600	415	Nil	160	52	171	<0.1	0.10	1292
Aug. 1972	"		108	475	14	7.2	1600	427	Nil	185	54	174			
Nov. 1972	"		No Sample												
Feb. 1973	"		No Sample												
May 1973	"		No Sample												
Aug. 1973	"		45	580	2	8.5	1800	273	16	430	4	7			1392
Nov. 1973	"		No Sample												
FEB. 1974	NO SAMPLE										(6) AVG 1969 - [illegible] = 165				193

THE ANACONDA COMPANY
WATER ANALYSIS

Murray 12.10.27.431

DATE	ANALYST		Cl ppm	SO_4 ppm	NO_3 ppm	pH	Cond. ppm	HCO_3 ppm	CO_3 ppm	Na ppm	Mg ppm	Ca ppm	Mn ppm	Fe ppm	TDS ppm
March 1964	Anaconda		No	Sample											
May 1964	"		81	433	15	7.5	1625	408	NIL	130	47	166	<0.10	<0.10	116
July 1964	"		No	Sample											
September 1964	"		No	Sample											
Nov 1964	"		No	Sample											
Jan 1965			No	Sample											
Mar 1965			No	Sample											
May 1965	Anaconda		83	457	10	7.4	1700	420	NIL	130	52	160	0.10	0.10	118
July 1965	"		85	457	11	7.5	1700	398	NIL	180					
Sept 1965			No Sample												
Nov 1965			No Sample												
Jan 1966			No Sample												
Mar 1966			No Sample												
May 1966	Anaconda		83	454	12	7.6	1625	469	Nil	140	45	165	<0.10	0.10	123
July 1966	"		83	444	11	7.5	1575	381	Nil	125					
Sept 1966	No Sample														
Nov 1966	No Sample														
Jan 1967	No Sample														
March 1967			No	Sample											
May 1967	Anaconda		85	456	19	7.4	1650	424	Nil	140	54	164	0.10	0.25	113
July 1967	"		86	419	12	8.1	1675	411	Nil	170					
Sept 1967			No	Sample											
Nov 1967			No	Sample											
Jan 1968	No Sample														
Mar 1968	No Sample														
May 1968	Anaconda		86	463	11	7.9	1900	397	Nil	130	49	167	<0.10	0.15	117
July 1968	"		89	464	8	8.2	1700	420	Nil	150					
Sept 1968	No Sample														5883
Nov 1968	No Sample										(5) 1964-1968 Ave TDS =				1177

WATER ANALYSIS

Murry 12.10.27.431

DATE		ANALYST	CL ppm	SO4 ppm	NO3 ppm	ph	Cond. umhos	HCO3 ppm	CO3 ppm	Na ppm	Mg ppm	Ca ppm	Mn ppm	Fe ppm	TDS ppm
July	1956	U.S.G.S.	72	392	6.9	7.3		392							
Dec.	1958	Anaconda	76	380	10	7.6				79	14	82	NIL	< 0.1	1025
Mar.	1959	Anaconda	77	337	15	7.2				116	48	49	NIL	< 0.1	1101
June	1959	"	78	380	10	7.4				131	46	154	< 0.1	0.2	1114
Sept.	1959	"	81	401	13	7.3				128	52	152	< 0.10	0.18	1050
Dec.	1959	"	81	387	6	7.3				135	47	161	< 0.10	0.35	1088
May	1960	Anaconda	82	403	4	7.8	1450	402	NIL	140	50	154	< 0.1	< 0.1	1119
July	1960	"	78	399	8	7.2	1410	410	NIL	110					
Sept.	1960	"	81	390	6	7.0	1500	409	NIL	110	43	160	< 0.1	< 0.1	1076
Nov.	1960	(DOWN FOR WINTER)	78	385	8.87	—	—	402	—	119	43	130	< 0.1	0.2	1082
Jan.	1961	(DOWN FOR WINTER)	—	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	1961	(DOWN FOR WINTER)	—	—	—	—	—	—	—	—	—	—	—	—	—
May	1961	Anaconda	77	391	8	7.8	1500	405	NIL	120	52	160	< 0.1	< 0.1	1101
July	1961	"	79	401	8	7.2	1500	409	NIL	120	55	167	< 0.1	< 0.1	1160
Sept.	1961	"	77	384	7	7.3	1650	416	NIL	155	48	152	< 0.1	< .10	1090
Nov.	1961	(Down For Winter)	—	—	—	—	—	—	—	—	—	—	—	—	—
Jan.	1962	(Down For Winter)	—	—	—	—	—	—	—	—	—	—	—	—	—
Mar.	1962	" " "	—	—	—	—	—	—	—	—	—	—	—	—	—
May	1962	Anaconda	79	415	7	7.2	1600	409	NIL	120	46	160	0.10	0.15	1117
July	1962	"	79	415	8	7.4	1600	398	NIL	100					
Sept	1962	"	83	436	7	7.2	1600	414	NIL	130	45	160	<0.10	<0.10	1110
Nov	1962	"	No	Sample											
Jan	1963		No	Sample											
March	1963		No	Sample											
May	1963	"	81	421	7	7.2	1600	419	NIL	120	36	174	<0.10	<0.10	1145
July	1963	"	86	449	8	7.2	1500	404	NIL	140					
Sept	1963	"	No	Sample											15378
Nov	1963	"	No	Sample											
Jan	1964	"	No	Sample								(14) samples 1958-1964 AVG			1098

San Andres

Ca Through Ion_Bal

Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	TDS (mg/l)	Cond(calc.) (micromhos	Ion_B (ratio)
#1 Deepwell	5/22/1958	UNK	214	74.0	---	302	617	< 0.100	205	671	1790	---	---
	4/20/1979	HMC	---	---	---	---	569	---	149	649	1500	---	---
	5/8/1980	HMC	---	---	---	---	---	---	191	801	1575	---	---
	5/8/1980	HMC	---	---	---	---	---	---	206	734	1800	---	---
	7/2/1980	HMC	---	---	---	335	651	---	---	714	---	1261	---
	10/23/1980	IL	244	59.0	24.0	330	614	0	358	569	2217	---	1.000
	5/11/1983	HMC	---	---	---	---	---	---	---	---	---	2325	---
	5/11/1983	HMC	---	---	13.0	315	622	0	248	708	1920	2273	---
	12/20/1983	HMC	---	---	---	---	---	---	---	---	---	2612	---
	12/20/1983	HMC	---	---	---	190	509	0	191	714	1780	2581	---
	3/21/1984	HMC	---	---	---	---	---	---	---	---	---	2604	---
	3/21/1984	HMC	---	---	---	---	---	---	---	---	---	2778	---
	3/21/1984	HMC	305	61.0	16.0	310	633	0	213	779	1950	2778	1.05
	5/25/1984	HMC	---	---	---	---	---	---	---	---	---	1737	---
	5/25/1984	HMC	---	---	---	---	---	---	---	---	---	1774	---
	7/31/1984	HMC	---	---	---	---	---	---	---	---	---	2496	---
	7/31/1984	HMC	---	---	---	---	---	---	---	---	---	2635	---
	7/31/1984	HMC	---	---	---	---	---	---	---	730	2130	2607	---
	9/28/1984	HMC	301	7.00	15.0	340	511	< 0.0010	206	807	1990	2613	0.990
	12/29/1984	HMC	---	---	---	---	---	---	---	734	2670	---	---
	3/13/1985	HMC	284	31.0	10.00	260	540	< 0.0010	156	755	1520	---	0.980
	6/27/1985	HMC	---	---	---	---	---	---	---	709	3080	2378	---
	9/13/1985	HMC	271	24.0	14.0	313	566	< 0.0010	184	782	1770	---	0.960
	12/20/1985	HMC	---	---	---	---	---	---	---	730	2920	---	---
	6/26/1986	HMC	---	---	---	---	---	---	---	742	1170	---	---
	9/17/1986	HMC	269	7.00	12.0	325	523	0.0010	191	713	1680	2582	0.990
	1/8/1987	HMC	---	---	---	---	---	---	149	712	2920	---	---
	3/30/1987	HMC	297	17.0	16.0	320	547	< 10.00	213	743	1710	---	0.990

San Andres

Ca Through Ion_Bal

Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	TDS (mg/l)	Cond(calc.) (micromhos	Ion_B (ratio)
#1 Deepwell	8/1/1994	ENER	---	---	---	---	---	---	---	723	1806	* 2525	---
	11/16/1994	ENER	219	72.0	12.0	317	---	---	---	696	1948	* 2631	---
	2/9/1995	ENER	---	---	---	---	---	---	---	689	1970	* 2814	---
	5/10/1995	ENER	165	74.0	11.5	307	459	< 0.100	215	580	1716	* 2623	1.09
	8/16/1995	ENER	---	---	---	---	---	---	---	742	999	* 1822	---
	11/15/1995	ENER	---	---	---	---	---	---	---	390	1071	* 1711	---
	2/15/1996	ENER	218	73.2	12.2	310	645	< 0.100	222	727	1999	* 3203	0.960
	5/15/1996	ENER	125	38.6	6.60	393	464	< 0.100	148	751	1720	* 2497	0.973
	8/12/1996	ENER	232	73.1	12.3	322	627	< 0.100	235	733	2030	---	0.992
	10/30/1996	ENER	207	65.3	10.4	309	582	< 0.100	210	701	1810	* 2648	0.978
	2/27/1997	ENER	---	---	---	---	---	---	---	440	1140	* 1822	---
	4/29/1997	ENER	193	61.7	10.4	303	608	0	183	630	1910	---	0.997
	7/24/1997	HMC	---	---	---	---	---	---	---	---	---	2367	---
	7/24/1997	ENER	---	---	---	---	---	---	---	641	1650	---	---
	11/3/1997	ENER	---	---	---	---	---	---	---	748	2010	* 2802	---
	2/4/1998	ENER	---	---	---	---	---	---	---	647	1860	* 2652	---
	5/5/1998	ENER	206	66.7	11.6	310	605	< 1.000	214	681	1940	---	0.980
	8/3/1998	ENER	---	---	---	---	---	---	---	641	1730	* 2443	---
	10/28/1998	ENER	---	---	---	---	---	---	---	755	1970	* 2709	---
	2/3/1999	ENER	---	---	---	---	---	---	---	811	1820	* 3081	---
	5/11/1999	ENER	---	---	---	---	---	---	---	752	2070	* 31.0	---
	8/17/1999	ENER	---	---	---	---	---	---	---	722	1980	* 2969	---
	11/2/1999	ENER	164	65.9	12.6	267	469	< 1.000	224	763	2040	* 3160	0.854
	2/1/2000	ENER	---	---	---	---	---	---	---	744	2000	* 2759	---
	4/27/2000	ENER	225	74.2	13.1	302	635	< 1.000	256	716	2030	* 3013	0.946
	8/2/2000	ENER	---	---	---	---	---	---	---	736	1780	* 2850	---
	11/21/2000	ENER	---	---	---	---	---	---	---	718	1910	* 2846	---
	5/16/2001	ENER	169	65.6	11.8	232	445	< 1.000	182	523	1660	---	1.04

* Signifies Specific Conductivity from HMC

San Andres

Ca Through Ion_Bal

Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	TDS (mg/l)	Cond(calc.) (micromhos	Ion_B (ratio)
#2 Deepwell	3/3/1980	HMC	---	---	---	---	---	---	160	---	---	---	---
	9/4/1980	HMC	---	---	---	---	549	---	135	668	1050	---	---
	10/23/1980	IL	207	62.0	13.0	259	558	0	139	669	1927	---	1.000
	11/6/1980	HMC	---	---	---	265	523	---	156	650	1050	---	---
	1/6/1981	HMC	---	---	---	---	---	---	149	659	---	---	---
	3/16/1981	HMC	---	---	---	250	---	---	149	653	1640	---	---
	5/4/1981	HMC	---	---	---	290	602	---	57.0	646	1680	---	---
	7/1/1981	HMC	---	---	---	265	561	---	178	656	1600	---	---
	9/16/1981	HMC	---	---	---	210	563	---	170	638	1510	---	---
	12/23/1981	HMC	---	---	---	160	374	---	163	662	1620	---	---
	3/1/1982	HMC	---	---	---	250	553	---	163	713	1690	---	---
	7/29/1982	HMC	---	---	---	290	558	---	156	713	1620	---	---
	1/25/1983	HMC	240	26.0	15.4	250	549	---	92.0	650	1660	---	1.01
	4/7/1983	HMC	---	---	---	250	531	---	104	664	1670	---	---
	6/16/1983	HMC	---	---	---	250	573	0	77.0	666	1590	---	---
	12/21/1983	HMC	---	---	---	250	481	0	156	670	1540	2578	---
	3/22/1984	HMC	250	49.0	14.0	245	549	0	156	669	1560	2125	1.01
	5/25/1984	HMC	---	---	---	---	---	---	---	---	---	2086	---
	5/25/1984	HMC	---	---	---	---	---	---	---	---	---	1930	---
	5/25/1984	HMC	---	---	---	---	---	---	---	---	---	1895	---
	7/31/1984	HMC	---	---	---	---	---	---	---	---	---	1998	---
	7/31/1984	HMC	---	---	---	---	---	---	---	---	---	2228	---
	7/31/1984	HMC	---	---	---	---	---	---	---	629	1620	2193	---
	9/24/1984	HMC	298	6.00	14.0	260	437	< 0.0010	170	702	1660	2384	1.02
	12/29/1984	HMC	---	---	---	---	---	---	---	779	2430	---	---
	3/13/1985	HMC	318	29.0	10.00	260	551	< 0.0010	156	762	1530	---	1.02
	6/27/1985	HMC	---	---	---	---	---	---	---	702	3310	2346	---
	9/12/1985	HMC	276	10.00	14.0	257	548	< 0.0010	156	682	1650	---	0.950

San Andres

Ca Through Ion_Bal

Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	TDS (mg/l)	Cond(calc.) (micromhos	Ion_B (ratio)
#2 Deepwell	3/3/1993	HMC	---	---	---	---	---	---	---	782	1870	2349	---
	5/14/1993	HMC	269	26.0	15.0	277	536	< 1.000	177	669	1800	2309	1.01
	9/1/1993	ENER	---	---	---	---	---	---	---	691	1761	* 2370	---
	11/8/1993	ENER	---	---	---	---	---	---	---	633	1808	* 2364	---
	2/9/1994	ENER	---	---	---	---	---	---	---	652	1777	* 2185	---
	5/5/1994	ENER	222	64.1	10.1	257	487	< 0.100	178	768	1808	* 2412	0.958
	8/1/1994	ENER	---	---	---	---	---	---	---	705	1714	* 2357	---
	11/16/1994	ENER	214	69.8	11.5	256	---	---	---	677	1799	* 2363	---
	2/9/1995	ENER	---	---	---	---	---	---	---	646	1790	* 2497	---
	5/10/1995	ENER	218	74.0	11.4	250	549	< 0.100	192	649	1817	---	1.01
	8/16/1995	ENER	---	---	---	---	---	---	---	679	1813	* 2553	---
	11/15/1995	ENER	---	---	---	---	---	---	---	704	1869	* 2526	---
	3/13/1996	ENER	267	86.7	12.0	253	560	< 0.100	244	823	1854	---	0.957
	5/14/1996	ENER	220	69.8	11.8	263	565	< 0.100	196	698	1836	* 2739	0.971
	8/28/1996	ENER	---	---	---	---	---	---	---	662	1860	---	---
	10/24/1996	ENER	228	72.6	11.8	264	555	< 0.100	206	700	1830	* 2647	0.988
	2/27/1997	ENER	---	---	---	---	---	---	---	702	1800	* 2350	---
	4/29/1997	ENER	214	67.8	11.2	246	539	0	181	627	1850	---	1.01
	7/24/1997	ENER	---	---	---	---	---	---	---	1031	1850	* 2492	---
	11/3/1997	ENER	---	---	---	---	---	---	---	730	1960	* 2699	---
	2/4/1998	ENER	---	---	---	---	---	---	---	642	1850	* 2521	---
	5/5/1998	ENER	212	69.3	11.4	257	558	< 1.000	195	661	1850	* 2597	0.976
	8/3/1998	ENER	---	---	---	---	---	---	---	697	1860	* 2475	---
	10/28/1998	ENER	---	---	---	---	---	---	---	716	1790	* 2453	---
	2/3/1999	ENER	---	---	---	---	---	---	---	732	1780	* 2619	---
	5/11/1999	ENER	---	---	---	---	---	---	---	693	1810	* 2806	---
	8/17/1999	ENER	---	---	---	---	---	---	---	704	1790	---	---
	11/2/1999	ENER	161	64.4	11.7	226	384	< 1.000	197	684	1800	* 3055	0.898

* Signifies Specific Conductivity from HMC

San Andres

Ca Through Ion_Bal

Sample Point Name	Date	Lab	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	Cl (mg/l)	SO4 (mg/l)	TDS (mg/l)	Cond(calc.) (micromhos	Ion_B (ratio)
0943	8/21/1997	ENER	9.20	5.60	2.90	654	215	5.80	91.0	1180	2040	* 3178	0.954
	8/18/1998	ENER	8.40	6.50	4.30	623	222	< 1.000	83.9	1100	1980	* 3046	0.973
	9/2/1999	ENER	---	---	---	---	---	---	---	1170	2070	* 3919	---
	9/2/1999	ENER	---	---	---	---	---	---	---	# 1100	# 2020	---	---
	8/23/2000	ENER	---	---	---	---	---	---	---	1070	2010	* 3832	---
	8/29/2001	ENER	---	---	---	---	---	---	---	1000	2040	* 3822	---
	8/29/2001	ENER	---	---	---	---	---	---	---	# 1000	# 2030	---	---
	11/13/2002	ENER	---	---	---	---	---	---	---	1080	2010	* 3840	---
	10/27/2003	ENER	---	---	---	---	---	---	---	1090	2030	* 2899	---
	3/9/2004	ENER	166	52.9	8.80	314	391	< 1.000	188	793	1830	* 2505	0.939
	12/8/2004	ENER	---	---	---	---	---	---	---	690	1720	* 2315	---
	4/19/2005	ENER	165	54.3	8.80	282	399	< 1.000	181	712	1680	* 2365	0.951
0951	4/15/1993	UNK	140	42.0	4.70	74.0	260	< 0.100	60.0	350	890	1422	1.04
	10/5/1993	UNK	---	---	---	---	---	---	55.0	340	830	---	---
	4/5/1994	UNK	160	46.0	5.20	75.0	340	< 0.100	57.0	350	890	1514	1.05
	8/31/1995	ENER	138	44.0	5.10	77.0	325	< 0.100	54.0	327	841	* 1262	1.02
	3/7/1996	ENER	87.2	69.0	9.80	117	113	< 0.100	88.9	567	993	* 1530	0.950
	10/22/1996	ENER	27.6	3.70	11.7	2.30	94.5	< 0.100	3.10	7.40	104	* 213	1.16
	8/21/1997	ENER	153	43.0	5.20	75.6	346	< 0.100	50.0	330	872	* 1388	1.05
	12/17/1997	ENER	148	42.3	5.20	73.0	340	< 0.100	51.0	314	867	* 1243	1.05
	8/18/1998	ENER	148	43.2	5.60	76.5	342	< 1.000	50.3	323	872	* 1478	1.05
	8/19/1999	ENER	---	---	---	---	---	---	---	333	842	---	---
	9/17/1999	ENER	---	---	---	---	---	---	---	313	855	* 1185	---
	10/19/1999	ENER	---	---	---	---	---	---	---	335	838	* 1221	---
	11/2/1999	ENER	---	---	---	---	---	---	---	335	857	* 1222	---
	12/10/1999	ENER	---	---	---	---	---	---	---	350	861	* 1200	---
	1/20/2000	ENER	---	---	---	---	---	---	---	333	824	* 1240	---
	8/9/2000	ENER	---	---	---	---	---	---	---	270	623	* 1226	---

Signifies Quality Control Sample

* Signifies Specific Conductivity from HMC

San Andres

pH Through Th-230

Sample Point Name	Date	Lab	pH (std. units)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Cr (mg/l)	V (mg/l)	Th230 (pCi/l)
#1 Deepwell	5/22/1958	UNK	---	---	---	---	1.20	---	---	---	---	---
	4/20/1979	HMC	---	0.212	0.220	0.0300	0.860	0	---	< 0.0100	---	---
	5/8/1980	HMC	7.10	< 0.0085	0.0200	0.0200	1.30	1.50	---	< 0.0100	---	---
	5/8/1980	HMC	7.00	< 0.0085	0.0200	0.0200	1.10	0.900	---	< 0.0100	---	---
	7/2/1980	HMC	7.40	< 0.0085	0.0200	< 0.0100	< 0.100	1.90	---	---	---	---
	10/23/1980	IL	7.00	0.0200	< 0.0500	< 0.0020	2.20	0.310	---	< 0.0100	< 0.0500	---
	5/11/1983	HMC	7.00	< 0.0085	0.0100	< 0.0100	0.700	0.500	---	< 0.0100	---	---
	12/20/1983	HMC	7.50	0.0068	0.0200	0.0100	2.50	2.30	---	< 0.0100	---	---
	3/21/1984	HMC	7.20	0.0102	0.0100	0.0100	12.0	2.40	---	< 0.0100	---	---
	9/28/1984	HMC	7.10	0.0136	0.0700	0.0100	8.40	0.200	---	< 0.0100	---	---
	3/13/1985	HMC	7.10	---	< 0.0100	0.0100	4.60	0.200	---	< 0.0100	---	---
	9/13/1985	HMC	7.00	< 0.0100	< 0.0100	< 0.0100	6.00	1.50	---	< 0.0100	---	---
	9/17/1986	HMC	7.60	< 0.0100	0.0100	0.0100	2.90	0.800	---	< 0.0100	---	---
	3/30/1987	HMC	7.70	< 0.0100	0.0100	0.0100	0.900	1.000	---	< 0.0100	---	---
	9/30/1987	HMC	7.00	< 0.0100	0.0100	< 0.0100	1.40	2.30	---	< 0.0100	---	---
	3/29/1988	HMC	7.60	0.0254	0.0100	0.0100	1.000	0.200	---	< 0.0100	---	---
	9/27/1988	HMC	7.50	0.0424	0.0100	< 0.0100	2.00	0.200	---	< 0.0100	---	---
	12/19/1989	HMC	7.00	0.0170	< 0.0100	< 0.0100	0.200	< 0.100	---	< 0.0100	---	---
	5/9/1990	HMC	7.30	< 0.0085	< 0.0100	0.0100	1.80	* 0.400	---	< 0.0100	---	---
	5/22/1991	HMC	7.10	0.0763	< 0.0100	< 0.0100	2.00	---	---	< 0.0100	---	---
	8/22/1991	BARR	---	---	---	---	---	3.10	---	---	---	---
	5/4/1992	HMC	7.20	0.0254	0.0100	0.0080	1.70	---	---	< 0.0100	---	---
	8/12/1992	ENER	---	---	---	---	---	2.70	---	---	---	---
	5/14/1993	HMC	7.40	0.0170	< 0.0100	< 0.0100	1.70	* 0.800	---	< 0.0100	---	---
	9/1/1993	ENER	---	0.0120	---	< 0.0010	---	---	---	---	---	---
	5/5/1994	ENER	7.17	0.0170	< 0.0300	< 0.0050	< 0.100	1.30	< 1.000	< 0.0500	< 0.0100	< 0.200
	8/1/1994	ENER	---	0.0160	---	< 0.0100	---	---	---	---	---	---
	11/16/1994	ENER	---	0.0130	---	< 0.0100	---	---	---	---	---	---

* Signifies Specific Conductivity from HMC

San Andres

pH Through Th-230

Sample Point Name	Date	Lab	pH (std. units)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Cr (mg/l)	V (mg/l)	Th230 (pCi/l)
#2 Deepwell	1/11/1978	HMC	7.60	0.0678	0.0300	0.0100	1.20	2.00	---	< 0.0100	---	---
	3/20/1978	HMC	7.50	0.0254	0.0100	< 0.0100	1.50	1.60	---	< 0.0100	---	---
	5/22/1978	HMC	7.20	0.187	< 0.0100	< 0.0100	2.10	2.90	---	< 0.0100	---	---
	7/24/1978	HMC	7.35	0.0424	0.0300	0.0400	1.20	1.60	---	< 0.0100	---	---
	9/15/1978	HMC	7.80	0.0170	0.0300	0.0200	1.20	1.60	---	< 0.0100	---	---
	11/10/1978	HMC	7.40	0.0509	0.0300	0.0100	1.80	2.90	---	< 0.0100	---	---
	1/12/1979	HMC	7.70	< 0.0085	0.0900	0.0100	2.10	1.50	---	< 0.0100	---	---
	3/5/1979	HMC	8.20	0.0594	0.110	0.0300	1.80	2.20	---	< 0.0100	---	---
	5/4/1979	HMC	8.10	0.0933	0.0800	0.0300	1.40	1.60	---	< 0.0100	---	---
	7/3/1979	HMC	8.00	0.102	0.100	0.0800	1.35	1.30	---	< 0.0100	---	---
	9/4/1979	HMC	7.70	0.0848	0.130	0.0100	1.35	1.80	---	< 0.0100	---	---
	11/2/1979	HMC	7.10	< 0.0085	0.0600	0.0100	1.20	0.200	---	< 0.0100	---	---
	1/3/1980	HMC	7.50	< 0.0085	0.0900	< 0.0100	1.20	0.700	---	< 0.0100	---	---
	3/3/1980	HMC	7.75	< 0.0085	0.0500	< 0.0100	1.10	1.10	---	< 0.0100	---	---
	9/4/1980	HMC	7.90	< 0.0085	0.0200	0.0200	1.20	0.600	---	< 0.0100	---	---
	10/23/1980	IL	7.40	< 0.0100	< 0.0500	< 0.0020	3.50	0.360	---	< 0.0100	< 0.0500	---
	11/6/1980	HMC	7.80	< 0.0085	0.0300	0.0200	1.10	1.10	---	< 0.0100	---	---
	1/6/1981	HMC	7.25	< 0.0085	0.0200	< 0.0100	5.60	1.000	---	< 0.0100	---	---
	3/16/1981	HMC	7.70	< 0.0085	< 0.0100	0.0200	1.000	1.70	---	< 0.0100	---	---
	5/4/1981	HMC	7.60	< 0.0085	0.0200	< 0.0100	1.05	1.40	---	< 0.0100	---	---
	7/1/1981	HMC	7.40	< 0.0085	0.0200	< 0.0100	1.10	0.500	---	< 0.0100	---	---
	9/16/1981	HMC	8.00	< 0.0085	0.0300	< 0.0100	5.40	3.80	---	< 0.0100	---	---
	12/23/1981	HMC	8.00	< 0.0085	0.0200	< 0.0100	1.20	1.20	---	< 0.0100	---	---
	3/1/1982	HMC	7.80	< 0.0085	0.0300	< 0.0100	1.10	1.30	---	< 0.0100	---	---
	7/29/1982	HMC	8.50	< 0.0085	0.0400	< 0.0100	1.000	4.60	---	< 0.0100	---	---
	1/25/1983	HMC	7.90	< 0.0085	< 0.0100	0.0300	1.30	1.000	---	< 0.0100	---	---
	4/7/1983	HMC	7.80	< 0.0085	0.0200	0.0300	0.700	2.40	---	< 0.0100	---	---
	6/16/1983	HMC	7.00	< 0.0085	< 0.0100	0.0100	1.30	0.900	---	< 0.0100	---	---

San Andres

pH Through Th-230

Sample Point Name	Date	Lab	pH (std. units)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Cr (mg/l)	V (mg/l)	Th230 (pCi/l)
#2 Deepwell	8/28/1996	ENER	---	0.0193	< 0.0300	0.0090	---	---	---	---	---	---
	10/24/1996	ENER	8.01	0.0083	< 0.0300	0.0090	1.96	0.400	< 1.000	< 0.0500	< 0.0100	< 0.200
	4/29/1997	ENER	7.83	0.0110	< 0.100	0.0040	2.25	0.800	---	< 0.0500	---	---
	11/3/1997	ENER	---	0.0250	0.0073	0.0060	---	---	< 1.000	---	< 0.0100	< 0.200
	2/4/1998	ENER	---	0.0109	---	0.0080	---	---	---	---	---	---
	5/5/1998	ENER	7.80	0.0117	< 0.0300	0.0080	1.71	0.300	---	< 0.0500	---	---
	11/2/1999	ENER	8.16	0.0106	< 0.0300	< 0.0100	2.05	< 0.200	---	< 0.0500	---	---
	4/27/2000	ENER	7.79	0.0119	< 0.0300	< 0.0050	2.39	0.400	---	< 0.0500	---	---
	5/2/2001	ENER	7.79	0.0100	< 0.0300	0.0090	3.17	< 0.200	< 1.000	< 0.0500	< 0.0100	0.400
	5/7/2002	ENER	8.10	0.0090	< 0.0300	0.0100	2.58	< 0.200	---	< 0.0500	---	---
	5/13/2003	ENER	7.86	0.0113	< 0.0300	0.0130	2.30	0.200	---	< 0.0500	---	---
	5/13/2003	ENER	# 4.89	# 0.0120	# < 0.0300	# 0.0090	# 2.50	# < 0.200	---	# < 0.0500	---	---
	5/10/2004	ENER	7.53	0.0109	< 0.0300	0.0070	2.61	< 0.200	---	< 0.0500	---	---
	5/4/2005	ENER	7.71	0.0091	< 0.0300	0.0120	2.40	0.500	---	< 0.0500	---	---
0806	7/25/1956	UNK	7.30	---	---	---	6.90	---	---	---	---	---
	9/18/1981	HMC	---	< 0.0085	0.0200	< 0.0100	3.60	0.500	---	---	---	---
	11/9/1994	ENER	7.58	0.0120	< 0.0300	0.0080	5.16	0.300	2.10	< 0.0500	< 0.0100	< 0.200
	7/24/1996	ENER	8.08	0.0130	< 0.0300	0.0080	4.06	< 0.200	---	---	---	---
	11/12/1996	ENER	7.79	0.0139	< 0.0300	0.0080	4.50	< 0.200	< 1.000	< 0.0500	< 0.0100	< 0.200
	9/2/1997	ENER	7.95	0.0100	< 0.0300	0.0070	4.42	< 0.200	---	---	---	---
	8/10/1998	ENER	7.93	0.0175	0.100	0.0090	4.30	0.500	---	---	---	---
	8/22/2000	ENER	---	0.0180	---	0.0080	---	---	---	---	---	---
	8/24/2001	ENER	---	0.0180	---	0.0110	---	---	---	---	---	---
	10/17/2002	ENER	---	0.0150	---	0.0100	---	---	---	---	---	---
	10/27/2003	ENER	---	0.0152	---	< 0.0050	---	---	---	---	---	---
	4/21/2005	ENER	7.62	0.0152	< 0.0300	< 0.0500	3.90	0.300	---	---	---	---
0943	8/28/1956	UNK	7.80	---	---	---	0.600	---	---	---	---	---

Signifies Quality Control Sample

San Andres

pH Through Th-230

Sample Point Name	Date	Lab	pH (std. units)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	Cr (mg/l)	V (mg/l)	Th230 (pCi/l)
0951	11/2/1999	ENER	---	0.0230	---	0.0030	---	---	---	---	---	---
	12/10/1999	ENER	---	0.0204	---	0.0060	---	---	---	---	---	---
	1/20/2000	ENER	---	0.0316	< 0.0300	< 0.0050	---	---	---	---	---	---
	8/9/2000	ENER	---	0.0030	---	< 0.0050	---	---	---	---	---	---
	10/17/2002	ENER	---	0.0280	---	< 0.0050	---	---	---	---	---	---
	10/27/2003	ENER	---	0.0314	---	< 0.0050	---	---	---	---	---	---
	12/8/2004	ENER	---	0.0272	---	0.0080	---	---	---	---	---	---
	4/25/2005	ENER	7.78	0.0281	< 0.0300	< 0.0500	4.40	0.200	---	---	---	---

HOMESTAKE
Grants Project

Homestake Mining Company of California
Alan D. Cox
Project Manager – Grants

6 November 2008

Larry Carver
P.O. Box 2970
Milan, NM 87021

Re: Analytical Data for Well 0806-R

Dear Mr. Carver:

Enclosed are copies of the *Laboratory Analytical Report* for the sample collected from your well 0806-R on September 24, 2008. Thank you for allowing us access to take water samples, and request your permission for continued access to take future samples.

Should you have any questions concerning this information, I can be reached at 287-4456 ext. 25.

Sincerely yours,

HOMESTAKE MINING COMPANY OF CALIFORNIA
Alan D. Cox

Enclosure

P.O. Box 98 / Hwy. 605 Grants, NM 87020 Tele: (505) 287-4456 Fax: (505) 287-9289

ENERGY LABORATORIES, INC. • 2393 Salt Creek Highway (82601) • P.O. Box 3258 • Casper, WY 82602
Toll Free 888.235.0515 • 7.235.0515 • Fax 307.234.1639 • casper@energ com • www.energylab.com

ENTERED NOV 0 4 2008

LABORATORY ANALYTICAL REPORT

Client: Homestake Mining Company
Project: Grants
Lab ID: C08091150-001
Client Sample ID: 0806-R

Report Date: 10/27/08
Collection Date: 09/24/08 12:37
Date Received: 09/29/08
Matrix: Aqueous

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
MAJOR IONS							
075 Alkalinity, Total as CaCO3	346	mg/L		1		A2320 B	09/30/08 20:56 / ljl
006 Carbonate as CO3	<1	mg/L		1		A2320 B	09/30/08 20:56 / ljl
005 Bicarbonate as HCO3	423	mg/L		1		A2320 B	09/30/08 20:56 / ljl
001 Calcium	234	mg/L		0.5		E200.7	10/15/08 14:08 / cp
007 Chloride	189	mg/L		1		E300.0	10/02/08 17:25 / dnp
002 Magnesium	76.8	mg/L		0.5		E200.7	10/15/08 14:08 / cp
039 Nitrogen, Nitrate+Nitrite as N	4.1	mg/L		0.1		E353.2	10/02/08 15:35 / eli-b
003 Potassium	9.9	mg/L		0.5		E200.7	10/15/08 14:08 / cp
004 Sodium	211	mg/L	D	4		E200.7	10/15/08 14:08 / cp
008 Sulfate	634	mg/L		1		E300.0	10/02/08 17:25 / dnp
PHYSICAL PROPERTIES							
009 pH	7.13	s.u.		0.01		A4500-H B	09/30/08 09:35 / dd
010 Solids, Total Dissolved TDS @ 180 C	1630	mg/L		10		A2540 C	10/01/08 09:13 / jah
...ETALS - DISSOLVED							
036 Molybdenum	<0.03	mg/L		0.03		E200.8	10/04/08 02:00 / ts
040 Selenium	0.008	mg/L		0.005		E200.8	10/21/08 18:06 / sml
015 Uranium	0.0178	mg/L		0.0003		E200.8	10/04/08 02:00 / ts
244 Uranium Precision (±)	0.00205	mg/L		0.00003		E200.8	10/04/08 02:00 / ts
114 Uranium, Activity	1.2E-08	uCi/mL		2.0E-10		E200.8	10/04/08 02:00 / ts
113 Uranium, Activity precision (±)	1.4E-09	uCi/mL		2.0E-11		E200.8	10/04/08 02:00 / ts
RADIONUCLIDES - DISSOLVED							
045 Radium 226	0.41	pCi/L				E903.0	10/14/08 15:07 / trs
245 Radium 226 precision (±)	0.15	pCi/L				E903.0	10/14/08 15:07 / trs
Radium 226 MDC	0.17	pCi/L				E903.0	10/14/08 15:07 / trs
256 Radium 226 altu	4.0E-10	uCi/mL				E903.0	10/14/08 15:07 / trs
258 Radium 226 altu precision (±)	2.0E-10	uCi/mL				E903.0	10/14/08 15:07 / trs
Radium 226 altu MDC	2.0E-10	uCi/mL				E903.0	10/14/08 15:07 / trs
DATA QUALITY							
192 A/C Balance (± 5)	3.13	%				Calculation	10/22/08 10:21 / sdw
194 Anions	25.8	meq/L				Calculation	10/22/08 10:21 / sdw
195 Cations	27.4	meq/L				Calculation	10/22/08 10:21 / sdw
079 Solids, Total Dissolved Calculated	1730	mg/L				Calculation	10/22/08 10:21 / sdw
200 TDS Balance (0.80 - 1.20)	0.940	unitless				Calculation	10/22/08 10:21 / sdw

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MDC - Minimum detectable concentration
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
D - RL increased due to sample matrix interference.

HOMESTAKE
Grants Project

Homestake Mining Company of California
Alan D. Cox
Project Manager – Grants

16 January 2008

Larry Carver
P.O. Box 2970
Milan, NM 87021

Re: Analytical Data for Well 0806

Dear Mr. Carver:

Enclosed are copies of the *Laboratory Analytical Report* for the sample collected from your well 0806 on October 2, 2007. Thank you for allowing us access to take water samples, and request your permission for continued access to take future samples.

Should you have any questions concerning this information, I can be reached at 287-4456 ext. 25.

Sincerely yours,

Alan D. Cox

HOMESTAKE MINING COMPANY OF CALIFORNIA
Alan D. Cox

Enclosure

2008 806 U 0.0178
U 0.0184 mg/L
2007 806 – U 0.0152 mg/L
2005 806 –

HOMESTAKE
GRANTS PROJECT

Alan D. Cox
Project Manager - Grants

17 June 2005

Larry Carver
P.O. Box 2970
Milan, NM 87021

Re: Analytical Data for Well 0806

Dear Mr. Carver,

Per your request enclosed is a copy of analytical data for a sample date of April 21, 2005 on your well as referenced. Thank you for allowing us access to take water samples, and request your permission for continued access to take future samples.

Should you have any questions concerning this information, I can be reached at 287-4456 ext. 17.

Sincerely yours,

HOMESTAKE MINING COMPANY OF CALIFORNIA
Alan D. Cox

Enclosure

LABORATORY ANALYTICAL REPORT

Client: Homestake Mining Company
Project: Not Indicated
Lab ID: C05041023-002
Client Sample ID: 0806

Report Date: 05/18/05
Collection Date: 04/21/05 14:00
Date Received: 04/26/05
Matrix: Aqueous

Analyses		Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
MAJOR IONS								
075	Alkalinity, Total as CaCO3	331	mg/L		1		A2320 B	05/02/05 13:43 / slb
006	Carbonate as CO3	<1	mg/L		1		A2320 B	05/02/05 13:43 / slb
005	Bicarbonate as HCO3	404	mg/L		1		A2320 B	05/02/05 13:43 / slb
001	Calcium	188	mg/L		0.5		E200.7	05/11/05 19:46 / cp
007	Chloride	193	mg/L		1		E200.7	05/11/05 19:46 / cp
002	Magnesium	63.8	mg/L		0.5		E200.7	05/11/05 19:46 / cp
039	Nitrogen, Nitrate+Nitrite as N	3.9	mg/L	D	0.2		E353.2	04/27/05 12:52 / jal
003	Potassium	9.3	mg/L		0.5		E200.7	05/11/05 19:46 / cp
004	Sodium	193	mg/L	D	0.5		E200.7	05/12/05 16:40 / cp
008	Sulfate	607	mg/L		1		E200.7	05/11/05 19:46 / cp
PHYSICAL PROPERTIES								
009	pH	7.62	s.u.		0.01		A4500-H B	04/27/05 15:07 / sl
010	Solids, Total Dissolved TDS @ 180 C	1510	mg/L		10		A2540 C	04/27/05 16:09 / sl
METALS - DISSOLVED								
036	Molybdenum	<0.03	mg/L		0.03		E200.8	05/05/05 09:47 / bws
040	Selenium	<0.05	mg/L		0.05		E200.8	05/05/05 09:47 / bws
015	Uranium	0.0152	mg/L		0.0003		E200.8	05/05/05 09:47 / bws
244	Uranium Precision (±)	0.00005	mg/L				E200.8	05/05/05 09:47 / bws
114	Uranium, Activity	1.0E-08	uCi/mL		2.0E-10		E200.8	05/05/05 09:47 / bws
113	Uranium, Activity precision (±)	3.1E-11	uCi/mL				E200.8	05/05/05 09:47 / bws
RADIONUCLIDES - DISSOLVED								
045	Radium 226	0.3	pCi/L		0.2		E903.0	04/28/05 15:45 / trs
245	Radium 226 precision (±)	0.3	pCi/L				E903.0	04/28/05 15:45 / trs
256	Radium 226 altu	3.0E-10	uCi/mL		2.0E-10		E903.0	04/28/05 15:45 / trs
258	Radium 226 altu precision (±)	3.0E-10	uCi/mL				E903.0	04/28/05 15:45 / trs
DATA QUALITY								
192	A/C Balance (± 5)	-3.52	%				Calculation	05/17/05 11:24 / smd
194	Anions	25.0	meq/L				Calculation	05/17/05 11:24 / smd
195	Cations	23.3	meq/L				Calculation	05/17/05 11:24 / smd
079	Solids, Total Dissolved Calculated	1470	mg/L				Calculation	05/17/05 11:24 / smd
200	TDS Balance (0.80 - 1.20)	1.03	dec. %				Calculation	05/17/05 11:24 / smd

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix interference.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

ENTERED JUN 0 9 2005

San Andreas Exhibit-3-A
Page 1-2

HOMESTAKE URANIUM MILL SUPERFUND SITE

Supplement to New Mexico Environment Department Superfund Oversight Section Residential Well Sampling and Analysis Plan

May 2007

CERCLIS # NMD007860935
Milan, New Mexico

Prepared by David L. Mayerson

Table 3: Wells proposed for ground water sampling for investigation of uranium contamination in Well RW-46 (HMC #986)

HMC (NMED) well number	Completion formation	Last ground water sample dissolved uranium concentration [mg/L] (Date sampled)	Rationale for sampling (gradient noted is relative to the SUBJECT WELL)
986 (RW-46)	San Andres	0.0458 (5/2/06)	SUBJECT WELL: Uranium concentrations exceeded standards in 2006, and represent an increase from only previous sampling in 1995
955 (RW-43)	San Andres	0.0054 (5/1/06)	Cross-gradient; located next to subject well
822	San Andres	0.096 (11/20/96)	Downgradient; sampling in 1995 and 1996 show increasing uranium concentration trend
949	San Andres	0.0078 (11/20/96)	Cross-gradient
943	San Andres	0.0149 (12/19/06)	Downgradient
987	San Andres	0.011 (11/3/95)	Cross-gradient
991	San Andres	<0.01 (11/8/95)	Cross-gradient
CW-43	Lower Chinle	0.0386 (11/14/06)	Cross-gradient in overlying formation
CW-39	Lower Chinle	0.0332 (11/28/06)	Upgradient in overlying formation.
942	Alluvium	0.0584 (8/9/05)	Cross-gradient in overlying formation
993	Alluvium	no data	Cross-gradient in overlying formation; closest well to subject well.

Homestake Partners Small Tailing Pond Exhibit-H Page 1-27
1960

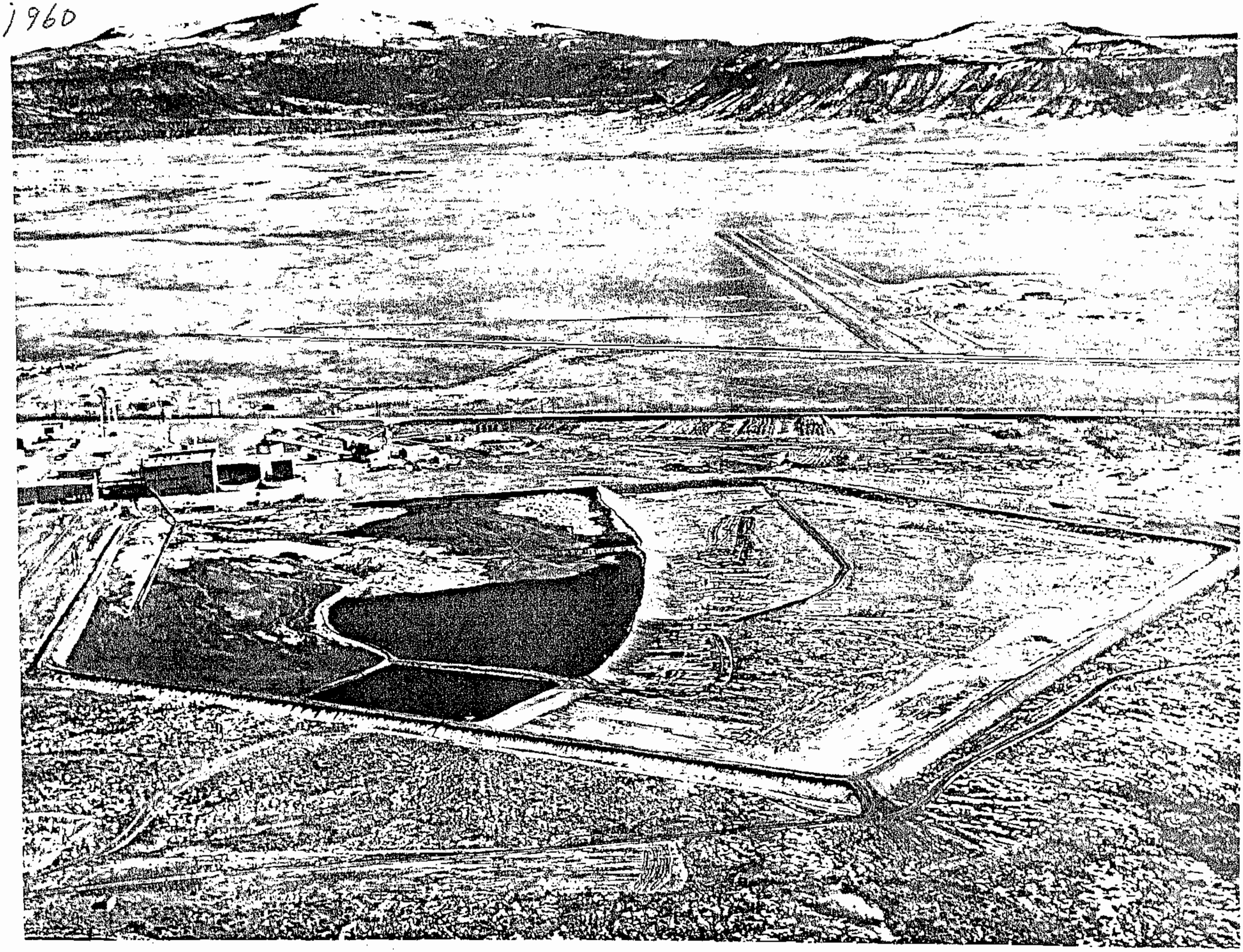
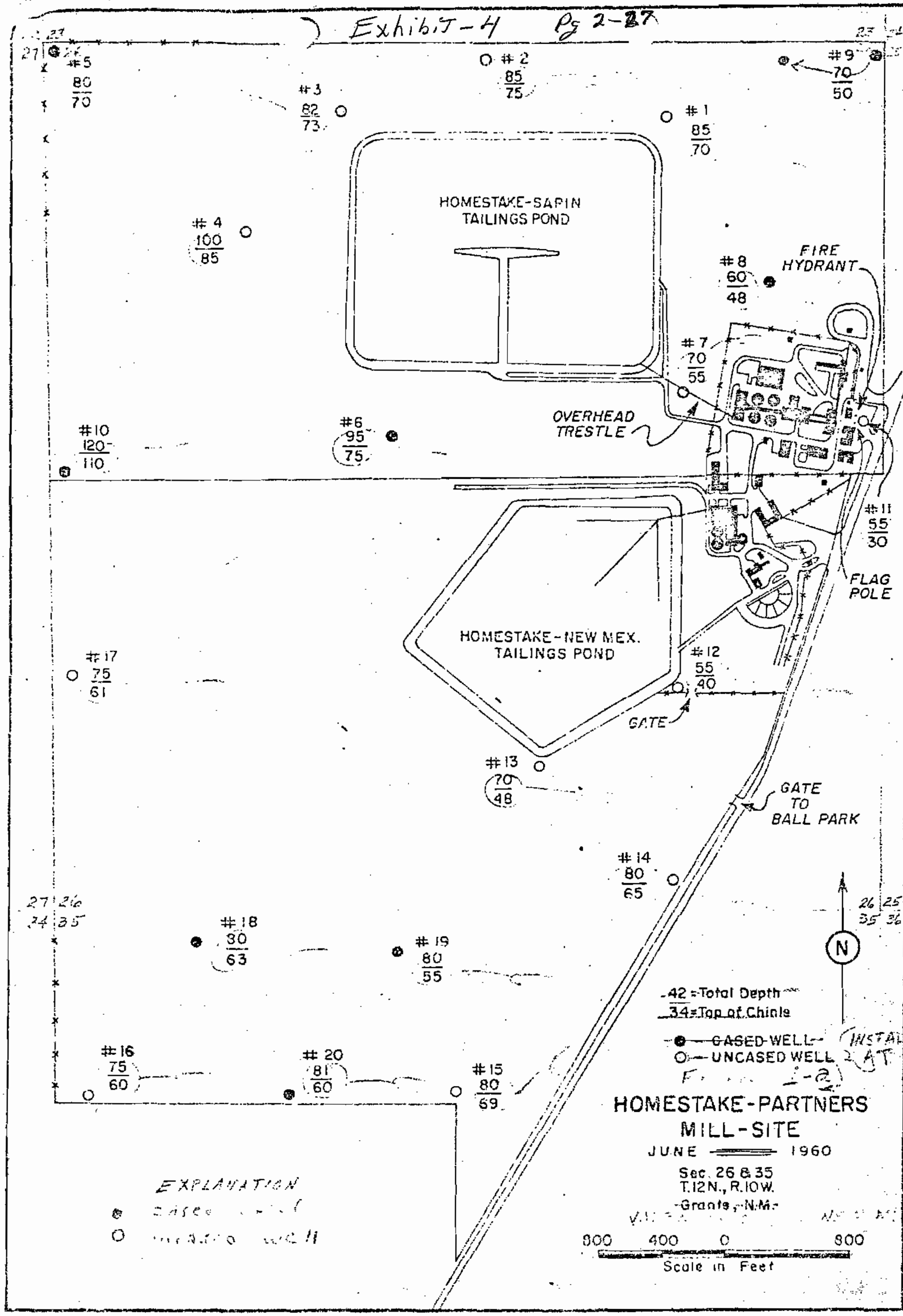


Exhibit-4 Pg 2-27



1 hr. leach at 50% of s[illegible]ls (cuttings

HOMESTAKE-SAPIN PARTNERS

ANALYTICAL LABORATORY REPORT

FORM 126

DESCRIPTION	DATE	% U_3O_8	X 10^{-7} mc/ml Ra	g/l U_3O_8	ppm Na_2CO_3	ppm $NaHCO_3$	ppm NaOH	Total Dis Solids PPM	X 10^{-7} mc/ml Ra
Cased Hole NE Corner of Sec. #9		.00035	10.25	.000035					
" # 1		.0222	1.71	.000018				420	.0427
" # 3	Cuttings only	.00037	4.70	.000013		84		285	
" # 8		.00057	12.81	.000020		210		375	
Hole near office - Comp 11		.00021	4.70	.000017					
Observation hole # 5				.000083		1915	54'7"	2250	.0596
" " # 6				.000068		588	51'5"	1500	.0673
" " # 9				.00010		563	55'10"	1200	.1110
" " -# X- "D"				.00014		445	47'	900	.0673
10							64'		
8									

$$10^{-7}\frac{\mu Ci}{ml} \times 10^{6}\frac{pC}{\mu Ci} \times 10^{3}\frac{ml}{l} = 10^{2}\frac{pC}{l}$$

C C T B ALLEN
J O JONES
L C DEJONG
C L HABERMAN

SIGNED [illegible]

DATE 7-11-60

HOMESTAKE - NEW MEXICO PARTNERS

DRILL HOLE SAMPLES

APRIL, 1960

SUSPENDED SOLIDS mg/l	SAMPLE NUMBER	DISSOLVED RADIUM	SUSPENDED RADIUM
Not measured	# 5	0.18 uug/L	3.89 uug/g
72,400	# 6	0.24 uug/L	2.56 uug/g
	# 8	1.79 uug/L	8.25 uug/g
	# 9	0.22 uug/L	6.91 uug/g
	#13	1.88 uug/L	22.3 uug/g
	#14	2.23 uug/L	21.6 ugg/g
	#15	1.19 uug/L	9.9 uug/g
6,730	#20 HS NP	24.3 uug/L	161 uug/g
843	North HS NP	0.79 "	5.66 "
900	East N MP	1.26 "	8.40

EID

Charles G. Caldwell, Director
Environmental Sanitation Services

408 Galisteo Street
Santa Fe, New Mexico

NEW MEXICO
DEPARTMENT OF PUBLIC HEALTH
SANTA FE

February 7, 1961

Mr. Don Akin
State Engineer Office
Capitol Building
Santa Fe, New Mexico

Dear Mr. Akin:

In August of 1960, Mr. Gene Chavez of your office collected a number of water samples from newly drilled testholes in the area of the Homestake-Sapin and Homestake-Partners uranium mills. These water samples were analyzed for Radium 226 by the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. Results of these analyses are as follows:

Sample No.	uug Ra/Liter
5	1.8
9	0.8
18	3.1
6	0.7

Normal background radiation for ground water in New Mexico should be 0.1 uug Ra/Liter. It is felt that these analyses indicate a definite pollution of the shallow ground water table by the uranium mill tailings' ponds. As this constitutes a fairly serious situation, our office intends to collect additional samples from these and other drill holes in the near future. We have requested that the Public Health Service perform analyses for Radium 226 for us on these additional samples. As soon as we are notified to the affirmative, we will proceed with our sampling program.

In view of our joint responsibility and interest in protection of the water quality, your continued interest is appreciated. Should you have any comments or suggestions for further surveillance of ground water in this area, please contact our office.

Sincerely,

John W. Hernandez
Associate Engineer
Environmental Sanitation Services

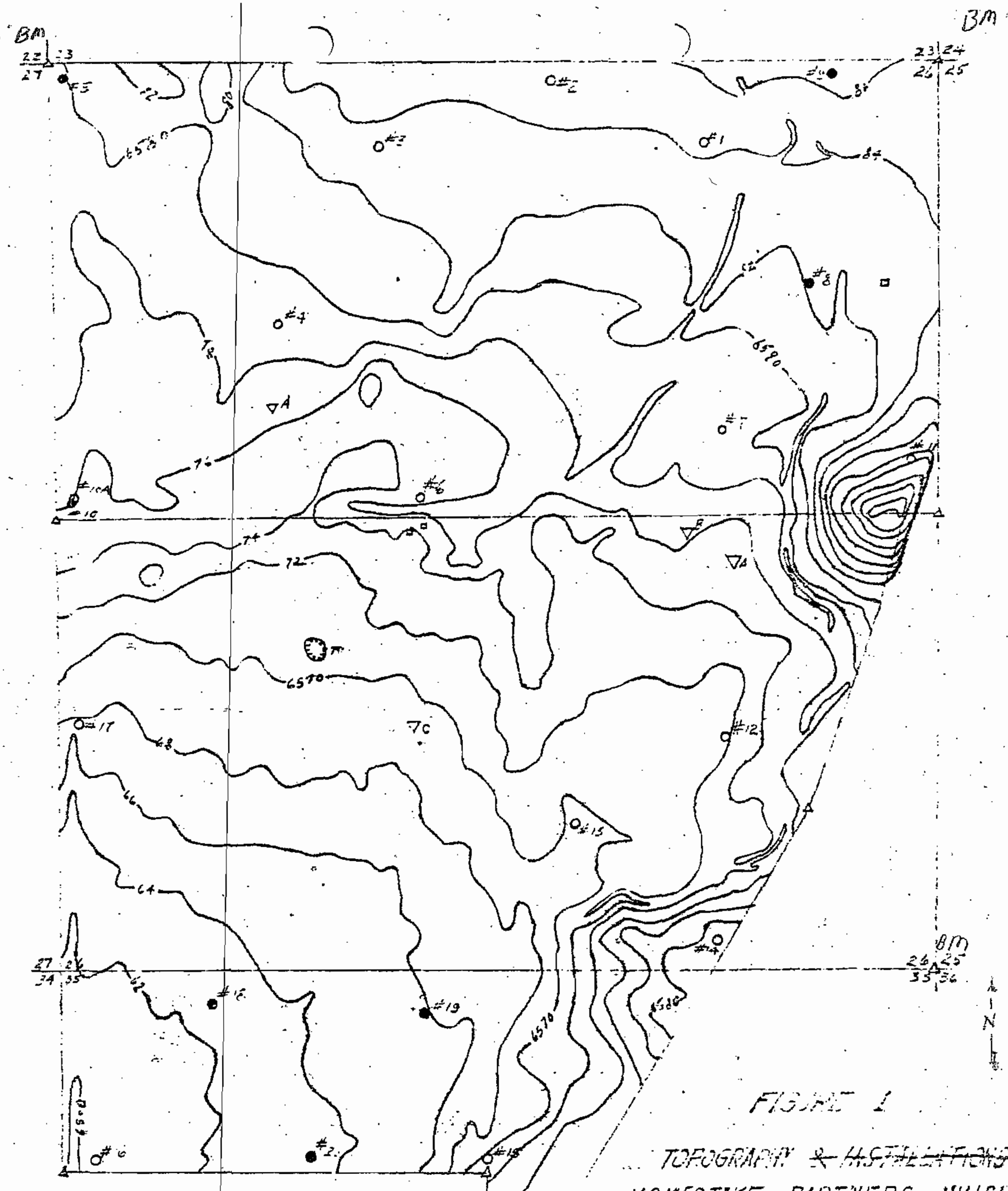


FIGURE 1

TOPOGRAPHY ~~& INSTALLATIONS~~

HOMESTAKE - PARTNERS MILLSI[TE]

Sec. 26 & 35, T.12N., R.10W.

Valencia County, New Mexico

(From original map of Homestake-Partners ...)

800 400 0 800

Scale in feet

EXPLANATION

Contour interval: 2 feet
(sea level datum)

- ● - cased monitor well
- ○ - uncased monitor well
- □ - water well
- ▽ - old exploratory well
- △ - section line monument

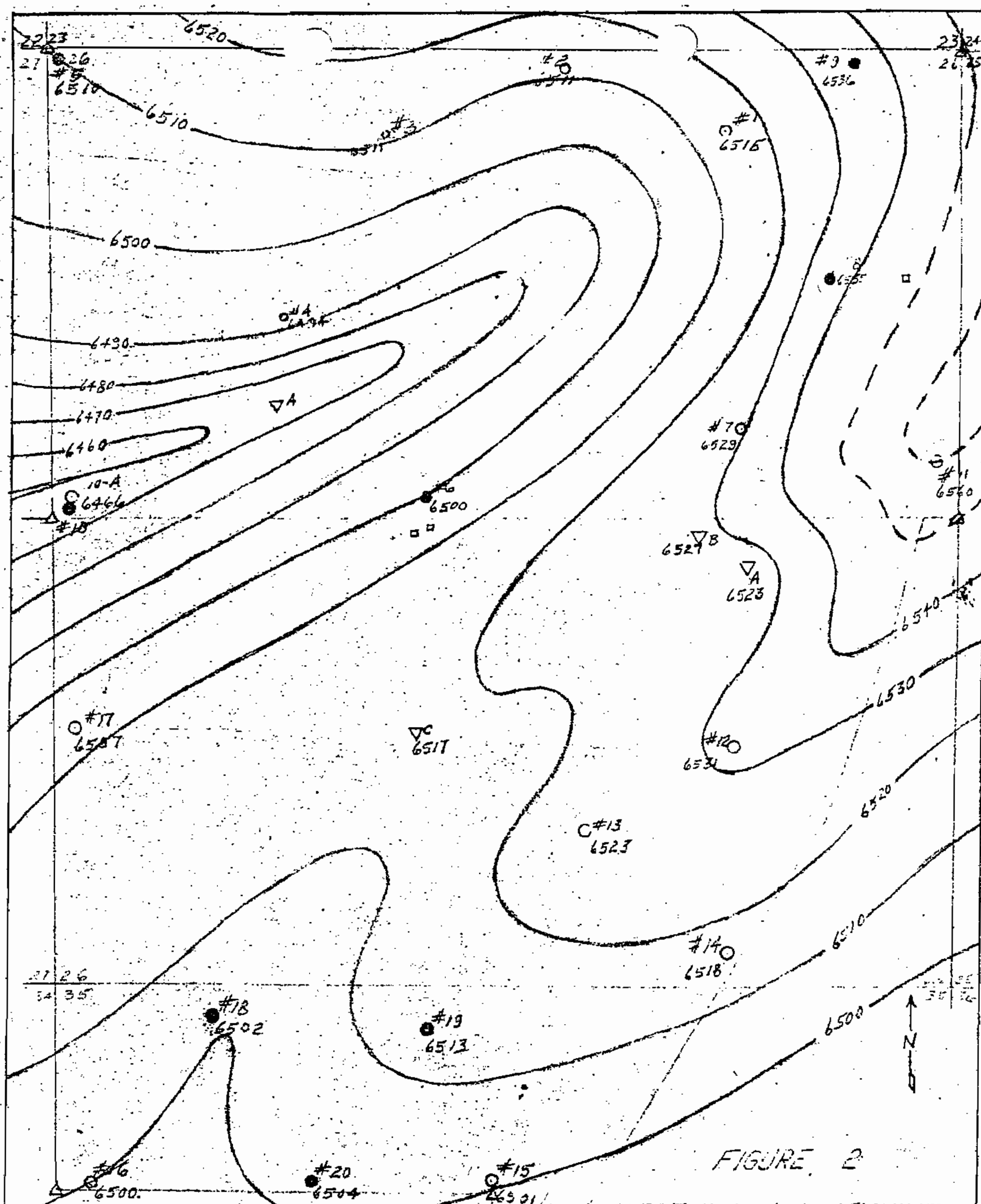


FIGURE 2

ALTITUDE & CONFIGURATION OF TOP OF CHINLE FORMATION

HOMESTAKE-PARTNERS MILLSITE

Secs. 26 & 35, T.12N., R.10W.

Valencia County, New Mexico

800 400 0 800

Scale in feet

EXPLANATION

Contour interval = 10 feet

(Sea level datum)

● – cased monitor well

○ – uncased monitor well

□ – water well

⊽ – old exploratory well

△ – section line monument

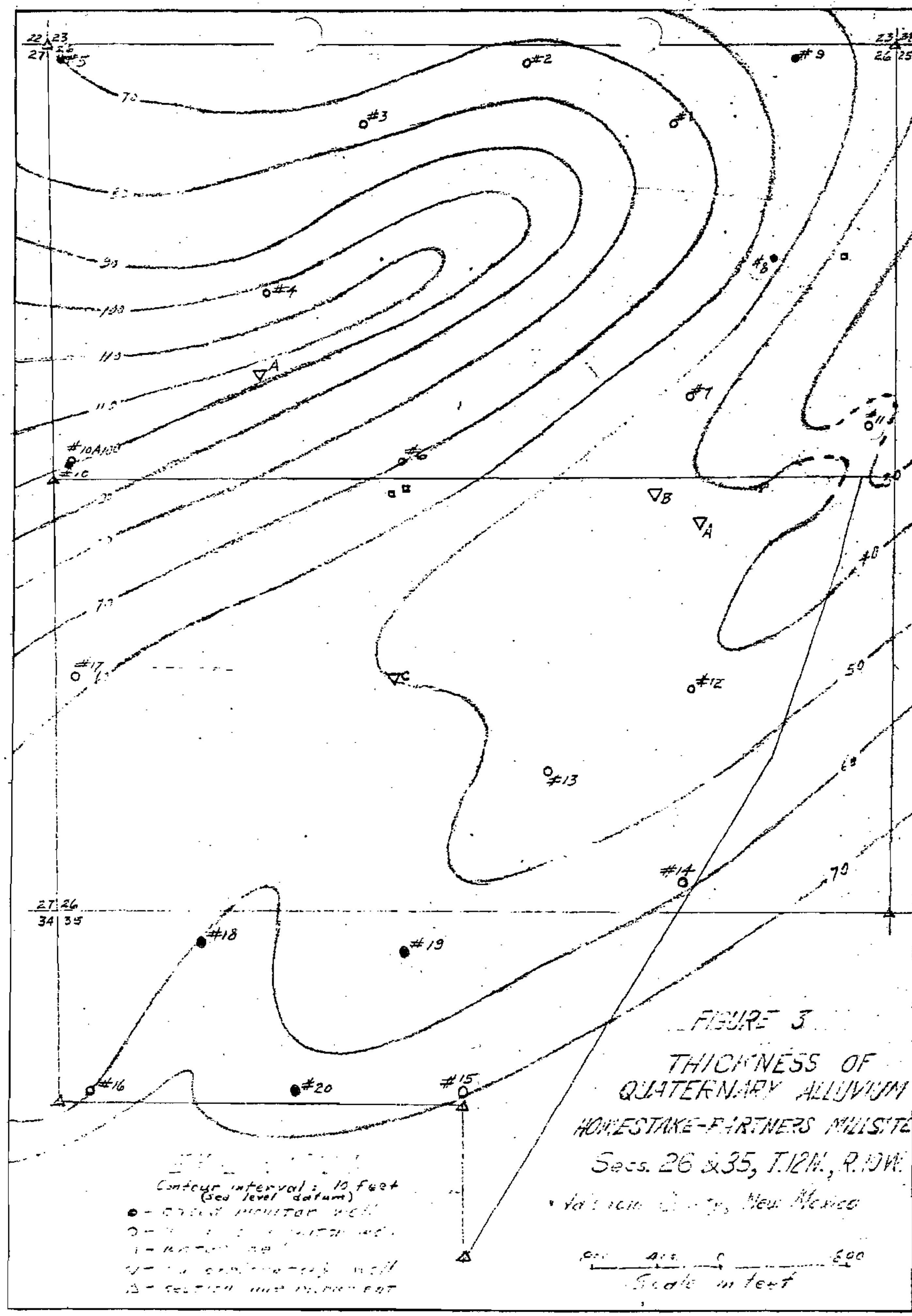


FIGURE 3

THICKNESS OF QUATERNARY ALLUVIUM

HOMESTAKE-PARTNERS MILLSITE

Secs. 26 & 35, T.12N., R.10W.

Valencia County, New Mexico

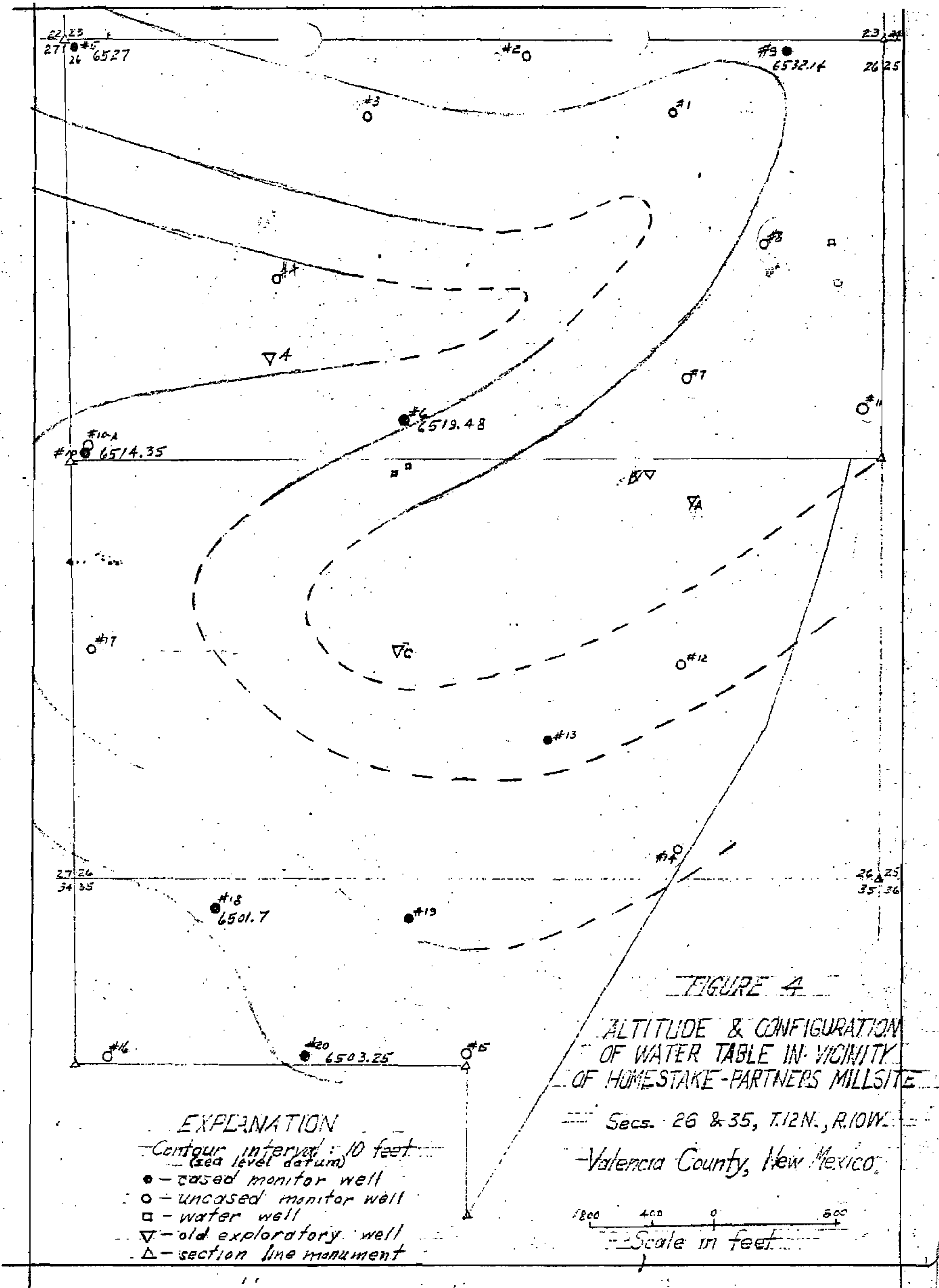


FIGURE 4

ALTITUDE & CONFIGURATION OF WATER TABLE IN VICINITY OF HOMESTAKE-PARTNERS MILLSITE

Secs. 26 & 35, T.12N., R.10W.

Valencia County, New Mexico

NEW M... DEPARTMENT OF PUBLIC ...TH
Environmental Sanitation Services

408 Galisteo Street
Santa Fe, New Mexico

Dated March 29, 1961

The following chemical analysis based upon a sample of water recently submitted from your supply has been reported to us by the chemistry department of the State Public Health Laboratory. It is herewith forwarded for your information.

TOWN Grants COUNTY Valencia DATE COLLECTED 3-8-61

OWNER OF SUPPLY Homestake-Sapin LAB NO. #33

POINT OF COLLECTION Drill Hole #15

RESULTS OF ANALYSIS

Color Units ______	Nitrates (as NO_3) 0.0 mg/l	Sulphates (as SO_4) 625 mg/l
Odor, Nature ______ TH. O. ______	Total Alkalinity (as $CaCO_3$) 208 mg/l	Phosphates (as PO_4) 0.0 mg/l
Turbidity ______ mg/l	Carbonate 0 mg/l	Fluorides (as F) ______ mg/l
Temperature ______ °C pH 8.2	Bicarbonate 208 mg/l	Magnesium (as Mg) 47 mg/l
Conductance 1873' Micromhos/cm	Hydroxide 0 mg/l	Iron (as Fe) (Total) ______ mg/l
Total Residue 3263 mg/l	Chlorides (as Cl) 52 mg/l	Manganese (as Mn) ______ mg/l
Non-filterable Residue 2040 mg/l	Sodium (as Na) 220 mg/l	Hardness (as $CaCO_3$) ______ mg/l
X Filterable Residue 1223 mg/l	Calcium (as Ca) 104 mg/l	

Remarks:

RECOMMENDED STANDARDS

Turbidity, not to exceed 10 mg/l
Color, not to exceed 20 mg/l
No objectionable taste or odor
Iron and manganese together should not exceed 0.3 mg/l
Magnesium should not exceed 125 mg/l
Fluorides should not exceed 1.5 mg/l
Chloride should not exceed 250 mg/l
Sulphate should not exceed 250 mg/l

Total Residue not to exceed 500 mg/l for a water of good chemical quality. However, if such water is not available, a total residue of 1,000 mg/l may be permitted.

Permissible pH about 10.6 at 26°C.

NEW M[illegible]O DEPARTMENT OF PUBLIC [illegible]TH
[illegible]nvironmental Sanitation Services

408 Galisteo Street
Santa Fe, New Mexico

Dated March 29, 1961

The following chemical analysis based upon a sample of water recently submitted from your supply has been reported to us by the chemistry department of the State Public Health Laboratory. It is herewith forwarded for your information.

TOWN Grants COUNTY Valencia DATE COLLECTED 3-8-61

OWNER OF SUPPLY Homestake-Sapin LAB NO. #36

POINT OF COLLECTION Drill Hole #14

RESULTS OF ANALYSIS

Color Units ____	Nitrates (as NO_3) ____ mg/1	Sulphates (as SO_4) 1600 mg/1
Odor, Nature ____ TH. O. ____	Total Alkalinity (as $CaCO_3$) 132 mg/1	Phosphates (as PO_4) 0.0 mg/1
Turbidity ____ mg/1	Carbonate 0 mg/1	Fluorides (as F) ____ mg/1
Temperature ____ °C pH 8.1	Bicarbonate 132 mg/1	Magnesium (as Mg) 56 mg/1
Conductance 2833 Micromhos/cm	Hydroxide 0 mg/1	Iron (as Fe) (Total) ____ mg/1
Total Residue 2637 mg/1	Chlorides (as Cl) 100 mg/1	Manganese (as Mn) ____ mg/1
Non-filterable Residue 588 mg/1	Sodium (as Na) 508 mg/1	Hardness (as $CaCO_3$) ____ mg/1
* Filterable Residue 2049 mg/1	Calcium (as Ca) 242 mg/1	

Remarks:

RECOMMENDED STANDARDS

Turbidity, not to exceed 10 mg/1
Color, not to exceed 20 mg/1
No objectionable taste or odor
Iron and manganese together should not exceed 0.3 mg/1
Magnesium should not exceed 125 mg/1
Fluorides should not exceed 1.5 mg/1
Chloride should not exceed 250 mg/1
Sulphate should not exceed 250 mg/1

Total Residue not to exceed 500 mg/1 for a water of good chemical quality. However, if such water is not available, a total residue of 1,000 mg/1 may be permitted.

Permissible pH about 10.6 at 26°C.

NEW M[illegible] DEPARTMENT OF PUBLIC [illegible]TH
Environmental Sanitation Services

408 Calisteo Street
Santa Fe, New Mexico

Dated March 29, 1961

The following chemical analysis based upon a sample of water recently submitted from your supply has been reported to us by the chemistry department of the State Public Health Laboratory. It is herewith forwarded for your information.

TOWN Grants COUNTY Valencia DATE COLLECTED 3-8-61

OWNER OF SUPPLY Homestake-Sapin LAB NO. #32

POINT OF COLLECTION Drill Hole #13

RESULTS OF ANALYSIS

Color Units		Nitrates (as NO_3)	7 mg/1	Sulphates (as SO_4)	1500 mg/1
Odor, Nature	TH. O.	Total Alkalinity (as $CaCO_3$)	208 mg/1	Phosphates (as PO_4)	0.0 mg/1
Turbidity	mg/1	Carbonate	0 mg/1	Fluorides (as F)	mg/1
Temperature	°C pH 8.2	Bicarbonate	208 mg/1	Magnesium (as Mg)	71 mg/1
Conductance	3342 Micromhos/cm	Hydroxide	0 mg/1	Iron (as Fe) (Total)	mg/1
Total Residue	4133 mg/1	Chlorides (as Cl)	172 mg/1	Manganese (as Mn)	mg/1
Non-filterable Residue	1605 mg/1	Sodium (as Na)	485 mg/1	Hardness (as $CaCO_3$)	mg/1
Filterable Residue	2528 mg/1	Calcium (as Ca)	269 mg/1		

Remarks:

RECOMMENDED STANDARDS

Turbidity, not to exceed 10 mg/1
Color, not to exceed 20 mg/1
No objectionable taste or odor
Iron and manganese together should not exceed 0.3 mg/1
Magnesium should not exceed 125 mg/1
Fluorides should not exceed 1.5 mg/1
Chloride should not exceed 250 mg/1
Sulphate should not exceed 250 mg/1

Total Residue not to exceed 500 mg/1 for a water of good chemical quality. However, if such water is not available, a total residue of 1,000 mg/1 may be permitted.

Permissible pH about 10.6 at 26°C.

NEW M[illegible] DEPARTMENT OF PUBLIC [illegible]TH

Environmental Sanitation Services

408 Galisteo Street
Santa Fe, New Mexico

Dated March 29, 1961

The following chemical analysis based upon a sample of water recently submitted from your supply has been reported to us by the chemistry department of the State Public Health Laboratory. It is herewith forwarded for your information.

TOWN Grants COUNTY Valencia DATE COLLECTED 3-8-61

OWNER OF SUPPLY Homestake-Sapin LAB NO. #37

POINT OF COLLECTION Drill Hole #9

RESULTS OF ANALYSIS

Color Units		Nitrates (as NO_3)	0.5 mg/l	Sulphates (as SO_4)	305 mg/l
Odor, Nature	TH. O.	Total Alkalinity (as $CaCO_3$)	328 mg/l	Phosphates (as PO_4)	0.0 mg/l
Turbidity	mg/l	Carbonate	0 mg/l	Fluorides (as F)	mg/l
Temperature	°C pH 8.4	Bicarbonate	328 mg/l	Magnesium (as Mg)	10 mg/l
Conductance	1470 Micromhos/cm	Hydroxide	0 mg/l	Iron (as Fe) (Total)	mg/l
Total Residue	91,079 mg/l	Chlorides (as Cl)	100 mg/l	Manganese (as Mn)	mg/l
Non-filterable Residue	90,228 mg/l	Sodium (as Na)	305 mg/l	Hardness (as $CaCO_3$)	mg/l
Filterable Residue	851 mg/l	Calcium (as Ca)	33 mg/l		

Remarks:

RECOMMENDED STANDARDS

Turbidity, not to exceed 10 mg/l
Color, not to exceed 20 mg/l
No objectionable taste or odor
Iron and manganese together should not exceed 0.3 mg/l
Magnesium should not exceed 125 mg/l
Fluorides should not exceed 1.5 mg/l
Chloride should not exceed 250 mg/l
Sulphate should not exceed 250 mg/l

Total Residue not to exceed 500 mg/l for a water of good chemical quality. However, if such water is not available, a total residue of 1,000 mg/l may be permitted.

Permissible pH about 10.6 at 26°C.

NEW MEX[illegible]O DEPARTMENT OF PUBLIC HE[illegible]TH
Environmental Sanitation Services

408 Galisteo Street
Santa Fe, New Mexico

Dated March 29, 1961

The following chemical analysis based upon a sample of water recently submitted from your supply has been reported to us by the chemistry department of the State Public Health Laboratory. It is herewith forwarded for your information.

TOWN Grants COUNTY Valencia DATE COLLECTED 3-8-61

OWNER OF SUPPLY Homestake-Sapin LAB NO. #31

POINT OF COLLECTION Drill Hole #8

RESULTS OF ANALYSIS

Color Units		Nitrates (as NO_3)	1 mg/1	Sulphates (as SO_4)	1650 mg/1
Odor, Nature	TH. O.	Total Alkalinity (as $CaCO_3$)	148 mg/1	Phosphates (as PO_4)	0.0 mg/1
Turbidity	mg/1	Carbonate	0 mg/1	Fluorides (as F)	mg/1
Temperature °C pH	8.1	Bicarbonate	148 mg/1	Magnesium (as Mg)	155 mg/1
Conductance	5162 Micromhos/cm	Hydroxide	0 mg/1	Iron (as Fe) (Total)	mg/1
Total Residue	16,048 mg/1	Chlorides (as Cl)	688 mg/1	Manganese (as Mn)	mg/1
Non-filterable Residue	12,561 mg/1	Sodium (as Na)	702 mg/1	Hardness (as $CaCO_3$)	mg/1
Filterable Residue	3487 mg/1	Calcium (as Ca)	331 mg/1		

Remarks:

RECOMMENDED STANDARDS

Turbidity, not to exceed 10 mg/1
Color, not to exceed 20 mg/1
No objectionable taste or odor
Iron and manganese together should not exceed 0.3 mg/1
Magnesium should not exceed 125 mg/1
Fluorides should not exceed 1.5 mg/1
Chloride should not exceed 250 mg/1
Sulphate should not exceed 250 mg/1

Total Residue not to exceed 500 mg/1 for a water of good chemical quality. However, if such water is not available, a total residue of 1,000 mg/1 may be permitted.

Permissible pH about 10.6 at 26°C.

NEW MEXICO DEPARTMENT OF PUBLIC HEALTH
Environmental Sanitation Services

408 Galisteo Street
Santa Fe, New Mexico

Dated March 29, 1961

The following chemical analysis based upon a sample of water recently submitted from your supply has been reported to us by the chemistry department of the State Public Health Laboratory. It is herewith forwarded for your information.

TOWN Grants COUNTY Valencia DATE COLLECTED 3-8-61

OWNER OF SUPPLY Homestake-Sapin LAB NO. #35

POINT OF COLLECTION Drill Hole #6

RESULTS OF ANALYSIS

Color Units	Nitrates (as NO_3) 0.0 mg/1	Sulphates (as SO_4) 800 mg/1 ←
Odor, Nature TH. O.	Total Alkalinity (as $CaCO_3$) 228 mg/1	Phosphates (as PO_4) 0.0 mg/1
Turbidity mg/1	Carbonate 0 mg/1	Fluorides (as F) mg/1
Temperature °C pH 8.0	Bicarbonate 228 mg/1	Magnesium (as Mg) 36 mg/1
Conductance 2056 Micromhos/cm	Hydroxide 0 mg/1	Iron (as Fe) (Total) mg/1
Total Residue 369,456 mg/1	Chlorides (as Cl) 68 mg/1	Manganese (as Mn) mg/1
Non-filterable Residue 368,034 mg/1	Sodium (as Na) 277 mg/1	Hardness (as $CaCO_3$) mg/1
Filterable Residue 1422 mg/1	Calcium (as Ca) 163 mg/1	

Remarks:

RECOMMENDED STANDARDS

Turbidity, not to exceed 10 mg/1
Color, not to exceed 20 mg/1
No objectionable taste or odor
Iron and manganese together should not exceed 0.3 mg/1
Magnesium should not exceed 125 mg/1
Fluorides should not exceed 1.5 mg/1
Chloride should not exceed 250 mg/1
Sulphate should not exceed 250 mg/1

Total Residue not to exceed 500 mg/1 for a water of good chemical quality. However, if such water is not available, a total residue of 1,000 mg/1 may be permitted.

Permissible pH about 10.6 at 26°C.

NEW MEXICO DEPARTMENT OF PUBLIC HEALTH
Environmental Sanitation Services

408 Galisteo Street
Santa Fe, New Mexico

Dated March 29, 1961

The following chemical analysis based upon a sample of water recently submitted from your supply has been reported to us by the chemistry department of the State Public Health Laboratory. It is herewith forwarded for your information.

TOWN Grants COUNTY Valencia DATE COLLECTED 3-8-61

OWNER OF SUPPLY Homestake-Sapin LAB NO. #34

POINT OF COLLECTION Drill Hole #5

RESULTS OF ANALYSIS

Color Units		Nitrates (as NO_3)	0.5 mg/l	Sulphates (as SO_4)	30 mg/l
Odor, Nature	TH. O.	Total Alkalinity (as $CaCO_3$)	392 mg/l	Phosphates (as PO_4)	0.0 mg/l
Turbidity	mg/l	Carbonate	0 mg/l	Fluorides (as F)	mg/l
Temperature °C	pH 8.4	Bicarbonate	392 mg/l	Magnesium (as Mg)	14 mg/l
Conductance	1889 Micromhos/cm	Hydroxide	0 mg/l	Iron (as Fe) (Total)	mg/l
Total Residue	9270 mg/l	Chlorides (as Cl)	288 mg/l	Manganese (as Mn)	mg/l
Non-filterable Residue	8302 mg/l	Sodium (as Na)	314 mg/l	Hardness (as $CaCO_3$)	mg/l
Filterable Residue	968 mg/l	Calcium (as Ca)	37 mg/l		

Remarks:

RECOMMENDED STANDARDS

Turbidity, not to exceed 10 mg/l
Color, not to exceed 20 mg/l
No objectionable taste or odor
Iron and manganese together should not exceed 0.3 mg/l
Magnesium should not exceed 125 mg/l
Fluorides should not exceed 1.5 mg/l
Chloride should not exceed 250 mg/l
Sulphate should not exceed 250 mg/l

Total Residue not to exceed 500 mg/l for a water of good chemical quality. However, if such water is not available, a total residue of 1,000 mg/l may be permitted.

Permissible pH about 10.6 at 26°C.

NEW MEXICO DEPARTMENT OF PUBLIC HEALTH
Environmental Sanitation Services

408 Galisteo Street
Santa Fe, New Mexico

Dated May 24, 1962

The following chemical analysis based upon a sample of water recently submitted from your supply has been reported to us by the chemistry department of the State Public Health Laboratory. It is herewith forwarded for your information.

TOWN Homestake-Sapin Mill COUNTY Valencia DATE COLLECTED 5-4-62

OWNER OF SUPPLY Homestake-Sapin LAB NO. 331

POINT OF COLLECTION Observation Well just off SE corner of tailings pond #7?

RESULTS OF ANALYSIS

Color Units colorless pH 7.3	Total Alkalinity (as $CaCO_3$) 176 mg/l	Potassium (as K) 3.9 mg/l
Odor, Nature normal Th. O.	Carbonate 0.0 mg/l	Fluorides (as F) 0.80 mg/l
Turbidity clear mg/l	Bicarbonate 176 mg/l	Magnesium (as Mg) 41 mg/l
Conductance 25°C 1990 Micromhos/cm	Hydroxide 0.0 mg/l	Iron (as Fe) (Total) 0.03 mg/l
Total Residue 1580 mg/l	Chlorides (as Cl) 89 mg/l	Manganese (as Mn) 0.00 mg/l
Nonfilterable Residue mg/l	Sodium (as Na) 228 mg/l	Hardness (as $CaCO_3$) 680 mg/l
Filterable Residue 1580 mg/l	Calcium (as Ca) 201 mg/l	Surfactants (as ABS) <0.05 mg/l
Nitrates (as NO_3) 11 mg/l	Sulphates (as SO_4) 807 mg/l	

Remarks:

RECOMMENDED STANDARDS

Turbidity, not to exceed 10 mg/l
Color, not to exceed 20 mg/l
No objectionable taste or odor
Iron and manganese together should not exceed 0.3 mg/l
Magnesium should not exceed 125 mg/l
Fluorides should not exceed 1.5 mg/l
Chloride should not exceed 250 mg/l
Sulphate should not exceed 250 mg/l

Total Residue not to exceed 500 mg/l for a water of good chemical quality. However, if such water is not available, a total residue of 1,000 mg/l may be permitted.

Permissible pH about 10.6 at 26°C.

4

NEW ME[illegible]O DEPARTMENT OF PUBLIC H[illegible]TH
Environmental Sanitation Services

408 Galisteo Street
Santa Fe, New Mexico

Dated May 24, 1962

The following chemical analysis based upon a sample of water recently submitted from your supply has been reported to us by the chemistry department of the State Public Health Laboratory. It is herewith forwarded for your information.

TOWN Homestake-Sapin Mill COUNTY Vlaencia DATE COLLECTED 5-4-62

OWNER OF SUPPLY Homestake-Sapin LAB NO. 333

POINT OF COLLECTION Observation Well just SW of tailings pond #6? or "Sapin test hole"

RESULTS OF ANALYSIS

Color Units colorless pH 7.2	Total Alkalinity (as $CaCO_3$) 203 mg/l	Potassium (as K) 9.6 mg/l
Odor, Nature normal Th. O.	Carbonate 0.0 mg/l	Fluorides (as F) 0.90 mg/l
Turbidity clear mg/l	Bicarbonate 203 mg/l	Magnesium (as Mg) 68 mg/l
Conductance 25°C 2525 Micromhos/cm	Hydroxide 0.0 mg/l	Iron (as Fe) (Total) 2.05 mg/l
Total Residue 2150 mg/l	Chlorides (as Cl) 108 mg/l	Manganese (as Mn) 0.50 mg/l
Nonfilterable Residue 10 mg/l	Sodium (as Na) 256 mg/l	Hardness (as $CaCO_3$) 1000 mg/l
Filterable Residue 2140 mg/l	Calcium (as Ca) 289 mg/l	Surfactants (as ABS) <0.05 mg/l
Nitrates (as NO_3) 92 mg/l	Sulphates (as SO_4) 1062 mg/l	

Remarks:

RECOMMENDED STANDARDS

Turbidity, not to exceed 10 mg/l
Color, not to exceed 20 mg/l
No objectionable taste or odor
Iron and manganese together should not exceed 0.3 mg/l
Magnesium should not exceed 125 mg/l
Fluorides should not exceed 1.5 mg/l
Chloride should not exceed 250 mg/l
Sulphate should not exceed 250 mg/l

Total Residue not to exceed 500 mg/l for a water of good chemical quality. However, if such water is not available, a total residue of 1,000 mg/l may be permitted.

Permissible pH about 10.6 at 26°C.

7

NEW [illegible] O DEPARTMENT OF PUBLI[illegible] [illegible]TH
Environmental Sanitation Services

408 Galisteo Street
Santa Fe, New Mexico

Dated May 24, 1962

The following chemical analysis based upon a sample of water recently submitted from your supply has been reported to us by the chemistry department of the State Public Health Laboratory. It is herewith forwarded for your information.

TOWN Homestake-Sapin Mill COUNTY Valencia DATE COLLECTED 5-4-62

OWNER OF SUPPLY Homestake-Sapin LAB NO. #334

POINT OF COLLECTION South Observation Well lat O well

RESULTS OF ANALYSIS

Color Units Colorless pH 7.6	Total Alkalinity (as $CaCO_3$) 184 mg/l	Potassium (as K) 1.9 mg/l
Odor, Nature Normal Th. O.	Carbonate 0.0 mg/l	Fluorides (as F) 0.80 mg/l
Turbidity Clear mg/l	Bicarbonate 184 mg/l	Magnesium (as Mg) 29 mg/l
Conductance 25°C 1665 Micromhos/cm	Hydroxide 0.0 mg/l	Iron (as Fe) (Total) 0.19 mg/l
Total Residue mg/l	Chlorides (as Cl) 40 mg/l	Manganese (as Mn) 0.00 mg/l
Nonfilterable Residue mg/l	Sodium (as Na) 205 mg/l	Hardness (as $CaCO_3$) 535 mg/l
✗ Filterable Residue 1310 mg/l	Calcium (as Ca) 167 mg/l	Surfactants (as ABS) $<$0.05 mg/l
Nitrates (as NO_3) 35 mg/l	Sulphates (as SO_4) 672 mg/l	

Remarks: Slight yellow brown sediment

RECOMMENDED STANDARDS

Turbidity, not to exceed 10 mg/l
Color, not to exceed 20 mg/l
No objectionable taste or odor
Iron and manganese together should not exceed 0.3 mg/l
Magnesium should not exceed 125 mg/l
Fluorides should not exceed 1.5 mg/l
Chloride should not exceed 250 mg/l
Sulphate should not exceed 250 mg/l

Total Residue not to exceed 500 mg/l for a water of good chemical quality. However, if such water is not available, a total residue of 1,000 mg/l may be permitted.

Permissible pH about 10.6 at 26°C.

PROGRESS REPORT ON CONTAMINATION

OF POTABLE GROUND WATER IN THE GRANTS-BLUEWATER AREA,

VALENCIA COUNTY, NEW MEXICO

INTRODUCTION

The uranium ore processing mills of Homestake-Sapin Partners and Homestake-New Mexico Partners are located on adjoining properties in the north half and south half, respectively, of Section 26, Township 12 North, Range 10 West, in Valencia County, New Mexico. Ore for these mills is extracted from mines in the Ambrosia Lake-Haystack Butte area north of the millsites. Disposal of process water from the two mills is effected into two unlined surface ponds. The maximum surface area of these ponds is approximately 62 acres and 41 acres, the larger figure being for the pond of the Homestake-Sapin Partners mill. The rate of discharge of effluent into either pond per unit of area of the pond is considerably more than the normal rate of evaporation in the general area of the mills (see Table 1, Climatological Summary). So far as is known, the ponds have never been filled to overflowing, therefore, under existing conditions it must be assumed that the part of the effluent not being evaporated is seeping into porous alluvial materials upon which the ponds have been constructed.

In the spring of 1960 the New Mexico Department of Public Health, in cognizance of the potential hazard of downward percolation of mill effluents from these ponds into aquifers containing potable supplies of water, ~~instigated a program to determine the incidence of radioactive contamination in~~ suggested a program of test drilling, water-level observation, and sampling so that possible contamination of ground water in the vicinity could be more readily detected.

~~potable ground waters occurring in the alluvium.~~ Subsequently, during the period of June 6 through June 9, 1960, twenty exploratory holes were drilled to determine the character and thickness of the alluvium and the configuration of the upper surface of the underlying bedrock. This drilling was accomplished with rotary tools using compressed air as a circulating medium whenever possible and water whenever necessary. The work was planned, directed, and paid for by the two companies concerned and witnessed by geologists of the U. S. Geological Survey and the State Engineer Office. Samples of cuttings obtained from these test holes were collected and examined by ~~this~~ the writer. Eight of the twenty holes drilled were cased with two-inch steel pipe and retained as monitor wells.

This report presents and evaluates the results of the exploratory drilling program and data obtained from the monitoring program through ~~March 8~~ March 31, 1961. The topography of the investigated area, the location of local water wells, and the location of exploratory holes referred to in this report with respect to the location of the mills and their disposal ponds are shown on Figures 1 and 1-a.

GEOLOGY

The material exposed at the surface in the general area of the ~~subject~~ mills consists of alluvium and occasional eroded basaltic flows of Pleistocene age. The alluvium ranges from 30 to 110 feet in thickness in the immediate vicinity of the millsites and ~~is capable of producing~~ produces limited quantities of ground water for domestic, stock, and irrigation use. Unconformably underlying the alluvium are red silty claystones and silty fine-grained sandstones comprising the Chinle formation of Triassic age. In the vicinity of the mills, the Chinle formation is approximately 400 feet thick but because of low permeabilities it yields water sufficient in quantity only for limited domestic and stock use. Immediately underlying the Chinle formation are the San Andres limestone and the Glorieta sandstone of Permian age. These ~~latter~~ formations have thicknesses of 75 and 100 feet, respectively, and constitute the principal aquifers from which water is ~~xxxxx~~ obtained for municipal needs of the towns of Grants, and San Rafael, for irrigation ~~the Bluewater valley~~, and for industrial needs of the uranium mills of the Anaconda Company ~~Corporation~~, Homestake-Sapin Partners, and Homestake-New Mexico Partners.

Lithologic descriptions and other basic data relating to the character of the materials encountered in the alluvium and the upper part of the Chinle formation during the drilling program at the millsites are appended to this report. Figures 2 and 3 show the altitude and configuration of the Chinle formation and thickness of the alluvium, respectively, as indicated by ~~these~~ data from the test holes and other available subsurface data in the vicinity of the millsites. The San Andres limestone and the Glorieta sandstone are of relatively little importance to the immediate problem of ground-water contamination in the general area of the subject mills and have not been studied as a part of this investigation.

WATER TABLE

Depths to water were measured by ~~this~~ the writer on June 15 and 16, 1960, in each of the eight exploratory holes retained as monitor wells. A tabulation of these data is as follows:

Monitor Well No.	Land Surface Altitude	Depth to Water Below Land Sur.	Water Level Altitude	Date of Measurement
5	6580	53.00	6527	6-16-60
6	6575	55.52	6519.48	6-16-60
8	6583	dry	——	6-16-60
9	6586	53.86	6532.14	6-16-60
10	6576	61.65	6514.35	6-16-60
18	6565	63.30	6501.70	6-15-60
19	6568	bridged	——	6-15-60
20	6564	60.75	6503.25	6-15-60

The altitude and configuration of the water table in the vicinity of the mill sites, as determined from these localized data, is shown on Figure 4.

CHEMICAL QUALITY OF GROUND- AND SURFACE-WATER SUPPLIES

Fourteen samples of water have been collected from ground- and surface-water sources in the general area of the Homestake mills by personnel of the State Department of Public Health, The Homestake-Sapin Partners, and the State Engineer Office during the course of this investigation. The results of laboratory analyses of these samples by the Arizona Testing Laboratories appear in Table 2.

RADIOACTIVITY OF SHALLOW G D-WATER SUPPLIES

Samples of water for radioactive analysis were collected from ~~X~~ wells No. 5, 6,9, and 10 in August 1960 by ~~this~~ the writer and Mr. DeJong, chief metallurgist for Homestake-Sapin Partners. Analyses of these samples by the Robert A. Taft Sanitary Engineering Center at Cincinnati, Ohio, show the following concentrations of Radium 226:

Point of collection	μμC Ra/liter
Monitor well No. 5	1.8
Monitor well No. 6	0.7
Monitor well No. 9	0.8
Monitor well No. 18	3.1

The normal background radiation for ground-water occurring in the Ogallala formation of eastern New Mexico[1/] ranges from 0.1 to 0.8 micromicrocuries per liter with a median of 0.1 micromicrocuries of radium per liter (μμC Ra/liter). Concentrations of uranium in water from the Ogallala formation ranged from 0.9 to 12 parts per billion (ppb) with a median of ~~XXX~~ 6.2 ppb. These concentrations are relatively high compared to the uranium content of 67 random samples from fluviatile sedimentary aquifers throughout the United States. The uranium concentration in these random samples ranged from 0.1 to 22 ppb with a median of 1.6 ppb or .0016 parts per million.

1/ Barker, F. B., and Scott, R. C., 1958, Uranium and radium in the Ground Water of the Llano Estacado , Texas and New Mexico: Am. Geophys. Union Trans., v. 39, p. 459-466.

The ~~above~~ tabulated spread of radioactive incidence, 0.7 to 3.1 μμC Ra/liter in the monitor wells, is probably caused by local anomalies in stratification affecting the lenticularity, porosities, and permeabilities within the ground-water body which subsequently affect the direction of groundwater movement and longevity of the presence of certain radioactively charged groundwaters at successive downgradient locations within the specific aquifer..

Well No. 18, with the greatest occurrence of radioactive material, is locally downdip from the Homestake-New Mexico Partners tailings ponds but only if one traces an imaginary line connecting the pond to the well which actually would follow the approximate axis of the southweat-trending nose shown in Figure 2. Referring to

Figures 2 and 3, Well No. 6, with the least occurrence of radioactive material, might have been expected to ~~run~~ have a higher incidence as it is directly down-structure, on the Chinle surface, from the Homestake-New Mexico Partners pond and nearer than Well No. 18. and approximately on horizontal strike with planes that literally circumvent the Homestake-Sapin tailings pond. Wells 5 and 9, on the other hand, are decidedly up-structure from the Homestake-Sapin pond with respect to the ~~ancient~~ Chinle surface.

In all fairness to the uranium mill operators, a test for radioactive contamination of strata communicable with near-surface seepage should include a control wherein resulting incidence of radioactivity would be nil or correlative with normal background radiation for the area in question. Provisional records of the Quality of Water Branch of the U. S. Geological Survey indicate that the radium content of waters from selected sources in McKinley and Valencia Counties may range from less than 0.1 micromicrocuries per liter, Bluewater Lake surface water, to 42 micromicrocuries per liter, mine drift water of the Westwater Canyon sandstone which is mined for uranium. (Table 3 lists radiological data from waters in McKinley and Valencia Counties, New Mexico.) This rate of increase in content of radium in waters from surface sources progressively deepening to the actual uranium-bearing horizons is readily obvious and apprehendible. Table 4 is a preliminary compilation of natural dissolved radium content of surface waters northwest of the Grants-Bluewater area. This data was compiled by the U. S. Public Health Service and is included merely as related background radiation material of the general area.

Accepting radial seepage of mill waste waters into a lensing aquifer, the foregoing results of analyses for Radium 226 are indicative of definite pollution of the shallow groundwater by the effluents; and this radial seepage may account for the incidence of radioactivity in waters collected from monitor wells 5 and 9.

The writer recognizes the fact that monthly reports are submitted by the two mill operators concerning data of tailings pond waste disposal to the Environmental Sanitation Services of the New Mexico Department of Public Health.

Notwithstanding the fact that Homestake-New Mexico Partners has undoubtedly gone to great pains and some expense in setting up measuring equipment and devices, the data submitted in monthly reports by this operator are inconclusive and misleading to the reader. They are presented by inventory methods using metered volumes and surveyed (calculated) volumes of mill waste waters as two systems of analysis, and leaving too much to the reader's imagination. Not being a statistician or a research analyst this writer cannot fully appreciate the value of these data as presented.

The data submitted by Homestake-Sapin Partners are presented by the method of accountability whereby the end result is a volume of mill effluent accounted for or unaccounted for and this presise information is more readily assimilated.

CONCLUSIONS

One cannot expect an erratic and lensing aquifer such as the shallow Quaternary alluvium of the subject area to be competent enough stratigraphically to follow an ideal hydraulic pattern that might coincide with that of adjacent horizons. In fact, it is reasonable to assume that the regional interformational direction of flow in more competent beds is actually trending to the north and northeast into the San Juan Basin.

RECOMMENDATIONS

It is hereby recommended that additional and more widespread sampling be performed in an effort to determine further radioactive pollution of Quaternary alluvial aquifers as opposed to natural background radiation of this currently prolific uranium-producing region.

Eugene A. Chavez, geologist
Technical Division, State Engineer Office

Roswell, New Mexico
April 3, 1961

Technical Assistance Services for Communities
Contract No.: EP-W-07-059
TASC WA No.: R6-TASC-002
Technical Directive No.: R6-Homestake Mining-02

Observations and Recommendations Regarding the Draft Focused Review of Specific Remediation Issues for the Homestake Mining Company (Grants) Superfund Site, February 2010 – Ground Water Considerations

May 6, 2010

Prepared by Wm. Paul Robinson and Chris Shuey
Southwest Research and Information Center

Introduction

This document provides the Bluewater Valley Downstream Alliance (BVDA) with observations and recommendations based on a technical review of the "Focused Review of Specific Remediation Issues: An Addendum to the Remediation System Evaluation (RSE) for the Homestake Mining Company (Grants) Superfund Site, New Mexico," a February 2010 Draft Report prepared by the U.S. Army Corps of Engineers' Environmental and Munitions Center of Expertise for the U.S. Environmental Protection Agency (EPA), Region 6.

The Draft Report is hereafter referred to as the "DRSE Report." The DRSE Report's scope of work, conclusions and recommendations are included as Appendix A. An overview of the remediation system at the Homestake Mining Company (HMC) site evaluated in the DRSE Report is provided in the November 2009 "Summary and Review of Application for Modification and Renewal of NMED Discharge Permit DP-725, Effluent Disposal Facilities for the Ground Water Remediation System at the Homestake Mining Company, Grants Reclamation Project, Milan, N.M. ["TASC Report"], among other sources.

This document addresses the following topics covered in the DSRE Report:

A. The burden of uranium and other contaminants in HMC tailings.
B. Monitoring well effectiveness and location.
C. Over prediction of flushing performance.
D. Identifying accurate ground water conditions in the Middle Chinle aquifer.
E. Life-cycle cost and effectiveness of remediation options identified.
F. Spray evaporation as a variable in determination of evaporation performance and evaporation options.
G. Remediation cost recovery.
H. Distribution and review of a revised DRSE Report for comment before completion of a Final RSE Report.

DRSE Report Observations and Recommendations

A. The Burden of Uranium and Other Contaminants in HMC Tailings.

Observations

The DRSE Report confirms concerns that the HMC remediation system has not effectively reduced the mass of uranium present in the tailings in the three decades since its inception, including the decade-long flushing program. The DRSE Report focuses heavily on uranium as an indicator of contamination and remediation with little discussion of other constituents of concern.

A reasonable approximation of the uranium remaining in the tailings is useful in assessing remediation performance and in the modeling and evaluation of future remedial options and actions. Bluewater Valley Downstream Alliance (BVDA) remains concerned, as expressed in comments on the 2009 Draft RSE (prepared by a different EPA contractor) that the DRSE Report significantly underestimates the remaining uranium in the tailings and therefore both underestimates the remaining burden of uranium in the tailings pile and overestimates the effectiveness of uranium removal in the HMC remediation system.

The DRSE Report at p. 6, sec 2.1.1 states, "Assuming the ore had an average of 0.15% uranium content and that the tailings had an average of 0.006% remaining uranium (based on information in [EPA's TENORM Report Vol. 1.] EPA 402-R-08-005, Table 3.13), the 22,000,000 tons of tailings would contain approximately 2.6 million pounds of uranium, or approximately 2.5 times the amount estimated to have been removed during the clean up effort through 2008."

The assumption of 0.15 percent uranium content in ore and 0.006 percent concentration of uranium remaining in the tailings assumes 96 percent recovery of uranium by mill operations with the remaining 4% being disposed of in the tailings piles (0.006% = 4% of 0.15%) and that each one percent of the uranium in the ore that remains in the tailings is equivalent to 660,000 pounds of uranium.

The assumption of 96 percent recovery of uranium cited in the DRSE Report is likely to over-predict recovery of uranium from mill operations at the HMC site, as it is higher than the uranium recovery rate reported for the specific mills on site or other uranium mills operating in New Mexico. Sources reporting on the HMC site's mill operations directly indicate higher ore grade and uranium content in tailings information than the more generic, non-site specific source cited in the DRSE Report.

The estimate of uranium remaining in the tailings in the DRSE Report is within the same "order of magnitude" as those identified in sources reporting data from the HMC site mills. However, the DRSE Report estimate is likely to be low by a factor of 2-3 or more from the actual amount of uranium in tailings if the HMC site-based sources are used. The low remaining uranium burden estimate in the DRSE Report therefore is likely to significantly overestimate the effectiveness of the HMC remediation system's uranium recovery efforts by a similar factor of 2-3 beyond the actual effectiveness of uranium recovery vs. uranium remaining in the tailings.

Sources of ore grade and uranium recovery information derived from HMC site mill data include:

1. New Mexico Bureau of Mines and Mineral Resources Open File Report 25: United Nuclear-Homestake Partners Uranium Milling Operations, Grants, New Mexico, 1968 ("OFR-25"), at http://geoinfo.nmt.edu/publications/openfile/downloads/OFR014-99/14-25/25/ofr_25.pdf. OFR-25 reports that in the 1960s, the UNHP mill at the HMC site operated with "grade of the ore averages [of] 0.21% U308 and the leach residue averages [of] .011% U308."

Assuming that "leach residue" is tailings, OFR-25 reports a 95 percent uranium recovery rate but 33 percent richer ore on average than the DRSE Report and almost twice (183%) the residual concentration of uranium in the tailings. Use of the higher grade and higher tailings uranium content data from OFR-25 would result in the uranium burden in the 22,000,000 tons of tailings at the HMC site of 4.8 million pounds. This amount of residual uranium is 4.5 times the approximately 1.1 million pounds of uranium recovered by the HMC remediation system, as the amount of uranium recovered would fall to only 23 percent of the uranium mass remaining in the tailings after cessation of operations from the 41 percent assumed in the DRSE Report.

2. "Process and Waste Characteristics at Selected Uranium Mills" 1962, U.S. Public Health Service Report W62-17, cited at p. 12, November 2009 "Summary and Review of Application for Modification and Renewal of NMED Discharge Permit DP-725, Effluent Disposal Facilities for the Ground Water Remediation System at the Homestake Mining Company, Grants Reclamation Project, Milan, N.M. ["TASC Report"] report of a 90% uranium recovery rate was attributed to the uranium mills operating on the HMC site in the late 1950s and early 1960s with an average ore grade of 0.15 – 0.2.

If the recovery rates in the USPHS Report are accurate, the amount of uranium remaining in the tailings would approach 6.6 – 8.8 million pounds and the percent of uranium mass recovered since HMC remediation began falls to the 12.5 percent to 16.7 percent of original uranium content in the tailings.

3. "New Mexico Energy Resources '81: The Annual Report of the New Mexico Bureau Mines and Mineral Resources, at http://www.osti.gov/bridge/servlets/purl/5391358-krD4W5/5391358.PDF, reported that, in 1980, operating uranium mills in New Mexico recovered "92 percent of contained U308 from ore in mill-feed operations."

If the DRSE Report assumed a 92 percent recovery rate rather than a 96 percent recovery rate for uranium for mills operating at the HMC site, the amount of uranium remaining in the tailings would double, and the percent of uranium recovered would fall by 50 percent.

Recommendations

The DRSE Report should be revised to present a higher estimate of uranium remaining in the tailings following mill operations. The estimate of uranium in the tailings piles should be revised upward by at least 100 percent, to the 4.8 – 6.6 million pound range, based on available technical literature reports addressing uranium remaining in tailings from the HMC site mills.

To the extent that one of the goals of the HMC remediation system is recovery or stabilization of the mass of uranium in the tailings, it seems to be extremely important to establish a conservative estimate of the baseline of uranium in the tailings based on site-specific data. Such an estimate is likely to be at least twice the estimate of uranium remaining in the tailings in the DRSE Report.

Though not a concern identified at the beginning of the RSE process, the DRSE Report should be revised to address HMC's technical approach, which emphasizes removal of uranium in solution in the tailings and considers the uranium not in solution to be relatively immobile and not likely to leak out of the tailings.

The DRSE Report should be revised to address, or comment generally on, the likely distribution of uranium remaining in the tailings between portion of uranium that may be dissolved in liquids in the large tailings pile and the remaining uranium not dissolved in liquids. The DRSE Report should also be revised to evaluate the effectiveness of the HMC remediation system to recover either or both portions of uranium remaining in tailings.

B. Monitoring Well Effectiveness and Location

At p. 14-15, the DRSE Report identifies elevated uranium concentration in wells DD and S11 on the west side of the large tailings pile. The elevated levels of uranium in these wells provide the basis for the DRSE Report's recommendations to:

1) "Further evaluate capture of contaminants west of the northwestern corner of the large tailings pile."
2) "Consider background concentrations of uranium in assessing site strategies for the alluvial aquifer."

1. Data presentation and reporting

Observations

The DRSE Report does not identify or discuss any of faulting and fracturing in the structures west of the large tailings piles and their potential influence on ground water quality, ground water flow rate or ground water flow direction in the graphic or narrative portions of the DRSE Report.

Figure 1 at p. 9 is not sufficiently detailed to identify the location of the wells of concern discussed in this section, as well as other sections of the Report. Figure 1 does not identify the locations of wells DD or S11 or the flow paths of concern on the west side of the tailings pile.

The figures that do illustrate the concentration vs. time plots have a wide variety of scales that prevent an effective comparison of the data reported. Recognizing that the data for the wells has been entered into a "excel" spreadsheet should allow a revised DRSE Report to include more illustrative graphs and charts.

Neither Figure 1 nor other figures identify the location of fault zones in the project area, the extent of the alluvial aquifer, or other geologic features that might influence ground water flow paths on the west side of the large tailings pile. The "scanned" well location maps posted by the RSE contractor team on the HMC RSE Quickr website provide additional detail but are not clearly integrated into the DRSE Report.

Recommendations

The graphics in the DRSE Report should be enhanced to identify key locations such as wells and pond sites, identify key geological and land use features, and provide more readable graphs of contaminant concentrations over time so that vertical scales are similar, rather than a selection among arithmetic and logarithmic scales, and check that the dates for data reported are readable.

2. Monitoring well DD and its associated potential ground water flow path

Observations

The DRSE Report shows a rising uranium trend in well DD in Figure 13 which results in a doubling of the uranium concentration in that well from the initial data point, which appears to be from the 1970s. The DRSE Report recommends the adoption of efforts to "further evaluate capture of contaminants west of the northwestern corner of the large tailings pile."

Recommendations

The DRSE Report should be supplemented to identify methods or techniques to identify and address a potential flow path in the area of those wells west and north of the large tailings pile.

The DRSE Report should be supplemented to identify specific additional investigations, such as borehole installations, non-intrusive geophysical methods, ground water control systems or other measures to identify and address the flow path in the well DD and S11 area.

The DRSE Report should be supplemented to include an assessment of the effect of the consistent rising trend in uranium concentrations in well DD on the value of a well at or near the location of well DD as the single down gradient monitoring well for ground water conditions for proposed pond EP3.

The DRSE Report should be supplemented to address the location of well DD and its associated flow path within the footprint of proposed evaporation pond 3 (neither well DD or EP3 are identified on Figure 1) and the challenges to investigation and remediation of the ground water with rising uranium content in the well DD/well S11 area north and west of the large tailings pile.

The DRSE Report should be supplemented to address the extent to which the elevated uranium in wells DD and S11 and the flow path that may be associated with them occurs under or down gradient of proposed pond EP3. Illustration of the location of wells DD and S11, the extent of fault zone on the west side of the large tailings, the extent of the alluvial aquifer and proposed location of EP3 would demonstrate the relationship of these features at the site.

The DRSE Report should be supplemented by the identification of recommendations regarding future investigations to determine variations in ground water flow rates and the pattern of contaminant concentrations in the fault zone on the west side of the large tailings pile compared to less fractured portions of the aquifer occurring in that fault zone, to define the ground water flow path in that area.

3. Capacity of well X to monitor for uranium in pond or tailings seepage compromised due to the influence of nearby wells used for injection of clean water

Observations

The DSRE Report's Adequacy of Plume Capture section states, at p. 8, that "Ground water concentrations of uranium and selenium in the alluvial aquifer in the vicinity of the small tailings pile have been significantly reduced (such as well X, a compliance point), though some wells have persistent concentrations well above the cleanup goals as represented by the plot of uranium for well K4."

Figure 3 on p. 8 illustrates the downward uranium trend in well X.

Of the hundreds of borehole completions on the HMC site, only two boreholes, monitoring wells X and DD, are completed in the configuration and in location that allows them to be designated as and function as monitoring and/or compliance wells...

Review of the uranium concentration trend for well X in Figure 3 shows that the uranium concentration in the well remained relatively steady for several decades before a steep drop in uranium concentrations was detected.

Figure 3 shows the drop in uranium concentration occurring after the construction of EP1 and the injection wells – including the "1993 J-line" of injection wells – along the south perimeter of EP1 and the small tailings pile. Figure 1 shows well X to be in such close proximity to injection wells that the symbols for the two are touching on the figure.

Review of the "Concentration Trends" spreadsheet prepared by the RSE Contractor team identifies the specific time when water quality changed dramatically in well X. At the March 28, 1994 sampling, the uranium concentration fell 90 percent from the previous quarterly sample: from 11.55 ppm in the November 3, 1993 sample to 1.19 ppm in the March 28, 1994 sample. Sulfate concentrations in well X dropped from 3,312 ppm to 978 ppm during the same period.

From the data in the "Concentration Trends" spreadsheet, the point in time when well X began sampling injection water rather than the alluvial aquifer is easily identified.

Though the DRSE Report documents a significant decrease in uranium detected in well X, it does not include a discussion of the likely influence of the injection of clean water in close proximately to well X on uranium concentrations in that well or its potential to monitor seepage from tailings piles or ponds on the HMC site.

The DRSE Report takes the data from monitoring well X at face value and does not identify the volume, quality or duration of clean water injected into the alluvial aquifer from the injection wells in close proximity to well X. The DRSE Report does not attempt to correlate the degree in uranium concentrations in well X with the use of the injection wells.

Recommendations

The DRSE Report should be revised to include recognition of the extensive injection well operation within a few meters of monitoring well X and the "almost instantaneous change" in uranium and sulfate concentrations in that well in 1994 when the injection system began.

The DRSE Report should be revised to reflect the likely effect of these long-term injections of clean water on the uranium concentrations in well X. The DRSE Report should also be revised to address the data in the "Concentration Trend" spreadsheet as a demonstration that the reduction in uranium concentrations in well X is attributable to dilution resulting from injection of clean water rather than demonstration some sort of reduction in uranium concentration due to uranium removal or control in the alluvial aquifer.

The DRSE Report should be revised to demonstrate that monitoring well X ceased being a well capable of monitoring seepage from EP1 when injection of clean water into nearby wells began only four years after the 1990 installation of EP1.

The likely influence of injection of clean water on the data generated at monitoring well X was a point of discussion during the recent NMED hearing on HMC DP-725. While NMED's recently issued final Discharge Plan DP–725 retains monitoring well X as the sole monitoring well down gradient of the four ponds, EP-1, EP-2, and the East and East Collection Ponds, witnesses for all parties recognized that the ground water concentrations at monitoring well X are "influenced" by injection and collection wells near it, as noted below.

The Hearing Officer's Report on the Record of the DP-725 Public Hearing, convened in January 2010 at p. 8, summary of the testimony of HMC witness Al Cox included:

> "On further cross-examination, Mr. Cox agreed that Monitoring Well X, at the south end of the small tailings pile near the injection wells, might be influenced by water from the injection wells and therefore not purely reflective of seep from Pond 1. Well X is a compliance well that will be looked at critically following remediation and cleanup. He would not use it now as a monitoring point to identify seepage from Pond 1." (transcript pp. 92-99)
>
> "Considering the maintenance required at the RO plant, and a multitude of other factors, a reasonable operating capacity is 540 gallons per minutes (GPM), 10% below the 600 gpm theoretical maximum." (transcript p. 99)

The Hearing Officer reported at pp. 8-9 that the testimony of HMC Witness Dr. Al Kuhn included:

> "[n]o leak detection system was installed at Pond 1, but there is an active collection system of wells there that would collect water that might seep away from Pond 1. The collection wells would likely not give an indication of leakage from Pond 1 because downstream of those wells is a set of injection well and it would be difficult to see a chemical signature that would be distinctly from Pond 1." (transcript, pp. 107 – 112)
>
> "The collection wells and other wells downstream will be effective after the ground water injection program is finished and can be used later to monitor residual seepage. If Pond 1 were leaking today, the leakage would be collected by the collection wells." (transcript, pp. 107 – 112)

The Hearing Officer reported at pp. 22-23 that HMC witness George Hoffman testimony included:

> "There are two wells DD and DD2, which will serve as monitoring wells to detect leakage at Pond 3. There is no monitoring well to the west because the western saturation of the alluvial aquifer is in that portion of the evaporation pond, Well X is naturally down gradient of the Small Tailings Pile and Evaporation Pond 1 is still a very appropriate monitoring point for the area. They [the injection wells] have reversed gradient, but when the ground water restoration program ceases, gradient ground water will turn and flow back to this area through Well X." (transcript pp. 368-370)

The Hearing Officer reported, at p. 30, that NMED witness Gerard Schoeppner:

> "Agrees that Well X is influenced by the injection wells and that it is appropriate to have a monitoring well at Pond 1 that would actually monitor potential leaks from that pond." (transcript pp. 440-443)

And that Mr. Schoeppner:

> "Agrees that monitoring well X is influenced by the injection of clean water nearby, but believes it is still useful in determining whether there are increased contaminant levels in the alluvium. (transcript pp. 445-448)

The Hearing Offer reported at p. 31 that BVDA witness Paul Robinson:

> "Understood that witnesses for the Applicant and the Bureau recognize that monitoring well X is not effective at detecting leaks that may occur from Pond 1 because of its close proximity to a row of injection wells. Based on that information, he recommends that the state supplement the discharge plan with a condition requiring the installation of a new monitoring well designed to serve as a leak detection monitoring point near Pond 1. The K-line of wells mentioned by Mr. Schoeppner were not constructed for use as monitoring wells but for other purposes." (transcript pp. 493, 497)

The DRSE Report should more accurately and effectively address the effectiveness of monitoring well X. The DRSE Report should also be revised to evaluate the significance of the influence of the injection wells and other aspects of the HMC injection and collection well system on uranium concentrations detected in monitoring well X.

The DRSE Report should be revised to include an evaluation of the adequacy of monitoring well X to demonstrate "plume capture" and detect contaminants leaking from the small tailing pile, or EP1 on top of the pile, or the other ponds and tailings pile, because of the influence of injection well water on the uranium concentration trend in monitoring well X.

The DRSE Report should be revised to address whether monitoring well X is located in a flow path that could detect seepage from the East and West Collection Ponds, EP-2 and EP-1 independent of the injection of clean water. If no flow path from the ponds to monitoring well X can be identified, the DRSE Report should be revised to identify a measure recommended by the RSE contractors to establish a more effective monitoring well in the south side of EP1, the other ponds south of the large tailings pile and the small tailings pile.

The DRSE Report should be revised to recommend additional monitoring well sites at locations not compromised by clean water injection, as is the case with well X, or rising uranium trends, as is the case with monitoring well DD, be identified to more effectively monitoring the current and near-term (10 yrs^{+}) potential leakage from the four ponds.

The DRSE Report should be revised to address the adequacy of the monitoring well and point of compliance well pattern in place at the HMC site and identify alternative monitoring well locations in recognition of the sources of dilution of uranium at well X and the rising uranium concentration trend at well DD.

C. Over Prediction of Flushing Performance

Observations

At p. 16, the DRSE Report states that the HMC ground water model "likely over predicts performance of flushing."

Recommendations

The DRSE Report should be revised to more fully address the implications and consequences of the over prediction of flushing performances and identify recommended actions to respond to the HMC ground water model's over prediction of flushing performance.

The DRSE Report should be revised to identify the degree to which performance of flushing has been over predicted.

The DRSE Report should be revised to identify mechanisms for more accurate prediction of flushing performance and the consequences of more accurate assessed flushing performance including, but not limited to, the likely ground water conditions and distribution of uranium and other contaminants in the large tailings pile if flushing is more accurately predicted.

The DRSE Report should be revised to identify the parameters in the HMC ground water model that lead to over prediction of flushing effectiveness and options for revising or recalibrating applicable models the models to provide more accurate predictions.

D. Identifying Accurate Groundwater Conditions in the Middle Chinle Aquifer

Observations

At p. 16, the DRSE Report states that the ground water conditions in the Middle Chinle aquifer at the site "don't make hydrologic sense."

Recommendations

The DRSE Report should be revised to include additional graphic information to identify the extent of the Middle Chinle and other aquifers on site and indicate where the Middle Chinle aquifer may be either used or affected by seepage from the tailings piles on the HMC site.

The DRSE Report should be revised to identify activities and investigations necessary to overcome the lack of accuracy regarding the hydrology of the Middle Chinle aquifer.

The DRSE Report should be revised to identify the significance of understanding the hydrology of the Middle Chinle aquifer to the HMC remediation system and the RSE Report.

E. Life-cycle Cost and Effectiveness of Remediation Options Identified

Observations

At pp. 27-28, the DRSE Report discusses the high cost of tailings removal to a prepared site. The DRSE Report includes a sustainability review of the tailings removal options but does not include a sustainability review of other remedial options identified.

In an April 9, 2010 e-mail, the RSE Contractor team leader stated, "We are working on the sustainability review of the other alternatives, including the continuation of the pump and treat system for some period of time, and for a slurry wall with limited pump and treat." In that email, the RSE contractor team leader did not indicate if or when that sustainability review will be made available for review or if/when a revised DRSE Report incorporating that information will be available for review.

Recommendations

The DRSE Report should be revised to provide lifecycle cost, emission or energy consumption comparisons among long-term remediation options identified in order to provide for balanced comparison of long-term costs for the range of alternatives identified in comparison to the cost, long-term potential for successful completion of remediation, and consequences of continuation of the HMC remediation system as proposed.

The DRSE Report should be revised to provide comparisons of the effectiveness of the physical barriers – slurry walls and reactive permeable barriers – that it recommends with the tailings removal options for long-term remediation of ground water at the site to meet performance objectives established in the Uranium Mill Tailings Radiation Control Act. The Act requires completion of closure and containment without active monitoring and maintenance as the measure of tailings reclamation effectiveness.

The DRSE should be revised to eliminate the recommendation that, "Relocation of the tailings should not be considered further given the risks to the community and workers and the greenhouse gas emissions that would be generated during such work" unless and until a balanced comparison of the full range of life-cycle costs and benefits, including considerations of long-term remediation effectiveness of the range of remedial alternatives, is incorporated in the Remediation System Evaluation.

The DRSE Report should be revised to identify and evaluate both 1) long-term monitoring and maintenance costs and 2) likelihood of long-term effectiveness of the range of alternatives identified, including continuation of the current remediation system and implementation of the alternatives identified. Alternatives include elimination of the flushing system, slurry wall, reactive permeable barriers, tailings removal and any other system with potential for long-term remediation success. Consideration of long-term remediation effectiveness and monitoring and maintenance costs should be incorporated into the RSE contractor team's sustainability review so that remediation performance as well as energy consumption and worker safety issues can be considered for all alternatives.

As tailings removal remains the only conceptual option that allows for elimination of the source of pollution from the HMC site, the DRSE Report should be revised to retain tailings removal as the sole remediation alternative that provides for the potential to minimize or eliminate the need for active long-term monitoring and maintenance after standards are attained.

F. Spray Evaporation as a Variable in Determination of Evaporation Performance and Evaporation Options

Observations

Little attention has been paid in the DRSE Report or in other analyses of the direct relationship between the scope of enhanced evaporation from the spray systems and size of the footprint of remediation-related ponds at the HMC site. Spray evaporation rates have been considered as a finite or fixed factor in the evaluation of evaporation at the HMC site rather than as a factor that can be adjusted to meet remediation needs by varying spray evaporation capacity or modifying evaporation technology.

To illustrate the effectiveness of spray system capacity on evaporation performance, two documents and a descriptive memo were forwarded to the RSE contractors on March 18. These documents, which are provided in Appendix B, provide a basis for identifying the full evaporation potential of spray systems in use at the HMC site and for developing a quantitative comparison of the characteristics of spray evaporation technologies. Appendix B includes a relatively brief paper by Gregory Flach and colleagues that provides an overview of "Evaporation Principles" and identifies and applies quantitative methods to evaluate the evaporation system performance for a site in Georgia.

Flach and colleagues also published another report that provides a quantitative evaluation of a "Turbomist evaporator", the same brand as one of the spray systems in place at the HMC site. That report, "Field Performance of a Slimline Turbomist Evaporator under Southeastern U. S. Climate Conditions" (available at http://sti.srs.gov/fulltext/rp2003429/rp2003429.pdf), is even more directly relevant for the HMC site because it explicitly discusses field evaluation of "Turbomist" evaporative sprayers from the same manufacturers as some of the spray systems in use at the HMC site and provides much more detailed information on field performance evaluation methods.

The HMC spray systems have not been subject to any quantitative evaluation of spray evaporation effectiveness and spray fallback as was conducted by Flach and others in their two reports. Neither have the current spray systems at the HMC site been the subject a quantitiative evaluation of the distribution of particulates and radionuclides, including but not limited to, radon and radon daughters in the liquids passing through the spray system.

DP-725 recently issued by NMED includes the following condition: "HMC shall operate the forced spray system such that the spray remains within the confines the ponds to the extent practicable. HMC shall submit plan to NMED for approval within 60 days of issuance of this

Discharge Permit outlining automated operation of the forced sprayers in EP-1, -2 and -3. The plan shall include, but is not limited to, wind conditions that sprayers will not be operated under such as maximum wind speed and wind direction, how automated controls will be utilized to shut-off sprayers, and how wind speed will be measured."

In the DP-725 Transcript at p. 19 -20 , Al Cox, a HMC witness stated,

> "In 2008, I believe, we commissioned … an electronic shutdown system on our pump systems for Evaporation Pond 1 in which it takes some … wind speed and direction data and information, and you can put in set points so that a sustained given mile per hour wind speed … and direction can actually shut those systems down. We still are at the present time trying to optimize that . . . system to determine what are the best set points to trigger an automatic shutdown from higher winds."

BVDA members report observing spray operations at the HMC ponds during recent spring days when sustained winds exceeded 40 miles per hour. Those observations indicate that spray operations may be continuing during high wind conditions.

Recommendations

The DRSE Report should be revised to identify a range of spray evaporation rate and technology options in comparison to the spray evaporation technology in use at the HMC site.

The DRSE Report should be revised to identify a range of spray evaporation rate options among the remediation system modifications it recommends and identify their implications for pond configuration, acreage and evaporation performance.

The DRSE Report should be revised to identify the need for, and scope of, a quantitative evaluation of spray evaporator performance and effectiveness including evaporative effect, fallback or sprayed fluids, and distribution of particulates and radionuclides including radon and radon daughters passing through the spray system.

The DRSE Report should be revised to identify the scope of data gathering and system monitoring considerations, including spray shut-down systems during high winds, necessary for effective performance of and effective evaluation of performance of the spray system in the "forced spray plan" required by DP-725.

G. Remediation Cost Recovery

Observations

The DRSE Report does not identify the cost of HMC remediation to date or project a cost for completion of remediation for any of the options considered except the tailings removal option.

The DRSE Report does not address the public cost of remediation at the HMC site; it does not acknowledge the cumulative cost to taxpayers of the federal government's payment of 51 percent of the remediation costs at the HMC site for the past three decades. Similarly, the DRSE Report does not identify the projected cost of future decades of remediation, monitoring and maintenance at the HMC site unless contamination is removed from the alluvial aquifer of the San Mateo Creek.

The DRSE Report does not identify or consider the opportunity for the application of EPA's "Federal Incentives for Achieving Clean and Renewable Energy Development on Contaminated Lands" (http://www.epa.gov/reg3wcmd/ca/pdf/Federal%20Incentives_050108.pdf) to the HMC site as a means to generate employment, energy and income to fund remediation at the site.

The potential to install large-scale renewable energy projects on the hundreds of acres in and around the HMC site that EPA's Federal Incentives program could support is facilitated by the flat slopes, existing electrical and transportation infrastructure, and large land areas on site that surround the tailings piles.

Implementation of a renewable energy project at the HMC site while remediation continues would provide employment and generate income to offset the long-term cost of remediation to taxpayers for the past 30 years of remediation and future remedial activities.

Recommendations

The DRSE Report should be revised to identify the anticipated cost and timeline for completion of remediation.

The DRSE Report should be revised to identify the opportunity to construct and operate a renewable energy system at the HMC site as a means to generate income to offset long-term remediation costs and to provide local employment.

H. Distribution and Review of a Revised DRSE Report for Comment Before Completion of a Final RSE Report

Observations

The RSE contractor team leader informed the RSE stakeholder team that the contractor would be recalculating evaporation rates and considering revisions to the DRSE Report in an e-mail dated April 9, 2010, more than six weeks after initial distribution of the DRSE Report and only two weeks before the April 23, 2010 informal comment period deadline. However, no revisions to the RSE review and completion schedule associated with these revisions have been identified.

It is not possible to accurately guess at which portions of the analysis, conclusions and recommendations in the DRSE Report related to evaporation options and pond configurations will or will not be influenced by the recalculation of evaporation rates.

Neither EPA or the RSE contractor team has identified a timetable for distribution and review of revisions to the DRSE Report to reflect long-term costs and benefits or other attributes of remediation alternatives the RSE contractor anticipates will be generated from the second point in the April 9, 2010 e-mail: “We are working on the sustainability review of the other alternatives, including the continuation of the pump and treat system for some period of time, and for a slurry wall with limited pump and treat.”

Consideration of long-term costs and performance assessments for remediation alternatives is critically important to the usefulness of the RSE process for future decision-makers. While the DRSE Report includes the conclusion that remediation progress to date is not sufficient to attain uranium concentration reductions to the 2 mg/l range by 2012, and therefore attainment of applicable standards by the projected date of 2017 is not likely to be possible, the DRSE Report provides no projection of an alternative date for completion.

Recommendations

The DRSE Report should be revised to identify the estimated length of time that the remediation options identified will be in place or operated and bases for estimation of the longevity of those remedial options.

To provide for stakeholder review of a revised DRSE Report before it is finalized, it is strongly recommended that EPA establish a timeline for distribution and RSE stakeholder review of a revised DRSE Report which includes the conclusions and recommendations resulting from the revised evaporation rate calculations and the “sustainability review” for remediation alternatives.

I. TASC Contact Information

E² Inc. Project Manager and Work Assignment Manager
Terrie Boguski, P.E.
913-780-3328
tboguski@e2inc.com

Wm. Paul Robinson and Chris Shuey, TASC Subcontractors
Southwest Research and Information Center
P.O. Box 4524, Albuquerque, NM USA 87196
505-262-1862
sricpaul@earthlink.net
sric.chris@earthlink.net

E² Inc. Program Manager
Michael Hancox
434-975-6700, ext 2
mhancox@e2inc.com

E² Inc. Director of Finance and Contracts
Briana Branham
434-975-6700, ext 3
bbranham@e2inc.com

E² Inc. TASC Quality Control Monitor
Paul Nadeau
603-624-0449
pnadeau@e2inc.com

Appendix A

Overview, Conclusions and Recommendations
from
"Draft Focused Review of Specific Remediation Issues for the Homestake Mining Company (Grants) Superfund Site,"
February 2010

"The current evaluation (DRSE, 2010) of the remediation efforts at the Homestake Mining Company (Grants) Superfund site has been conducted on behalf of the US Environmental Protection Agency (US EPA) by a technical team at the US Army Corps of Engineers Environmental and Munitions Center of Expertise composed of Dave Becker, Carol Dona and Brian Healy. The evaluation supplements a previous Remediation System Evaluation (RSE) conducted for the site by Environmental Quality Management (EQM, 2008)."

ISSUES

"Specific issues addressed in DRSE 2010 as identified in the Scope of Work include:

1) Evaluate the capture of contaminant plumes in the alluvial and Chinle aquifers;
2) Evaluate the overall strategy of flushing contaminants from the large tailings pile with discharge of wastes to on-site evaporation ponds and to identify and compare alternatives;
3) Assess potential modifications to the current ground water treatment plant to improve capacity;
4) Evaluate the projected evaporation rates for the existing on-site ponds and for a proposed evaporation pond west of the on-site tailings piles, as it may affect the restoration activities at the site;
5) Assess the adequacy of the monitoring network at the site;
6) Evaluate the current practice of irrigating with untreated water; and
7) Evaluate the smaller of the two tailings piles at the site as a potential source of contamination and the future need for a more conservative cap than the radon barrier.

"A stakeholder involvement process to exchange information has been since the initiation of the project, the DRSE the reports that the RSE team has found very helpful in focusing and facilitating the analysis.

"The DRSE analysis of current and past environmental conditions as well as the current and past operations of the extraction, injection, and treatment systems has been conducted by the ACE RSE Team following a single site visit in April, 2009."

CONCLUSIONS

"Major conclusions in the RSE include:

A. Ground water quality restoration is very unlikely to be achieved by 2017;

B. Flushing of the large tailings pile is unlikely to be fully successful at removing most of the original pore fluids or to remediate the source mass present in the pile due to heterogeneity of the materials;

C. Long screened intervals in wells complicate the interpretation of water quality in and below the large tailings pile;

D. The mill site may be an additional source of contaminants;

E. Control of the contaminant ground water plumes seems to depend on both hydraulic capture and dilution;

F. There may have been widespread impacts on the general water quality (e.g., ions such as sulfate) of the alluvial aquifer since mill operations began, but the limited amount of historical data precludes certainty in this conclusion;

G. Upgradient water quality has declined over time, primarily in the western portion of the San Mateo drainage and this may be affecting concentrations in northwestern portions of the study area;

H. Ground water modeling has generally been done in accordance with standard practice. The seepage modeling likely overestimates the efficiency of flushing of the tailings;

I. The control of a uranium plume in the Middle Chinle aquifer may be incomplete;

J. There are no apparent impacts to the San Andres aquifer though data are limited;

K. There is no indirect evidence of leakage from the evaporation and collection ponds, though the interpretation of water level and concentration data are complicated by the significant injection and extraction conducted in the immediate vicinity of the ponds;

L. Current constraints to treatment plant operations include the evaporative capacity of the ponds, clarifier operations, and possibly reverse osmosis capacity;

M. Evaporation rates for the ponds at the site are likely to be in the 65-80 gpm on an annual basis when accounting for climatic conditions and salinity of the pond contents;

N. The monitoring program at the site is extensive and not clearly tied to objectives. There may be redundancies in the network in a number of locations in the alluvial aquifer. Additional monitoring points are necessary in the Upper and Middle Chinle aquifers to better define plume extent and migration. Monitoring frequency is irregular but generally from semi- annual to annual. Air particulate monitoring appears adequate to assess anticipated effluent releases from the site, however, there is a need to confirm assumptions. The potential for release of radon from the STP/evaporation pond area should be assessed;

O. Irrigation with contaminated water has resulted in accumulation of site contaminants in the soil of the irrigated land. These accumulations are unlikely to migrate to the water table over time, however;

P. Water used for irrigation could be successfully treated with ion-exchange technology

RECOMMENDATIONS

"Based on the DRSE analysis conducted, a number of recommendations were offered including:

A. The flushing of the tailings pile should be curtailed;
B. Simplification of the extraction and injection system is necessary to better focus on capture of the flux from under the piles and to significantly reduce dilution as a component of the remedy;
C. Further evaluate capture of contaminants west of the northwestern corner of the large tailings pile;
D. If not previously assessed, consider investigating the potential for contaminant mass loading on the ground water in the vicinity of the former mill site;
E. Further investigate the extent of contaminants, particularly uranium, in the Upper and Middle Chinle aquifers and resolve questions regarding dramatically different water levels among wells in the Middle Chinle;
F. Consider geophysical techniques, such as electrical resistivity tomography to assess leakage under the evaporation ponds;
G. Assure decommissioning of any potentially compromised wells screened in the San Andres Formation is completed as soon as possible;
H. Consider construction of a slurry wall or Permeable Reactive Barrier (PRB) around the site to control contaminant migration from the tailings piles. The decision for implementing such an alternative would depend on the economics of the situation;
I. Relocation of the tailings should not be considered further given the risks to the community and workers and the greenhouse gas emissions that would be generated during such work;
J. If geotechnical considerations allow, consider expansion of the evaporation pond on the small tailings pile as means to enhance evaporative capacity;
K. Consider either the pretreatment of high concentration wastes in the collection ponds as is currently being pilot tested, or adding RO capacity to increase treatment plant throughput and reduce discharge to the pond;
L. Develop a comprehensive, regular, and objectives-based monitoring program;
M. Quantitative long-term monitoring optimization techniques are highly recommended;
N. Adjust Air Monitoring Program to perform sampling of radon decay products to confirm equilibrium assumption, consider use of multiple radon background locations to better represent the distribution of potential concentrations and assess the radon gas potentially released from the evaporation ponds, especially during active spraying; and
O. Though risks appear minimal with the current irrigation practice, consider treatment of contaminated irrigation water via ion exchange prior to application as a means to remove contaminant mass from the environment.

Appendix B

TO: Dave Becker, RSE Team

FROM: Paul Robinson

DATE: March 18, 2010

SUBJECT: Evaporation Rate Materials

TURBOMISTER – a supplier of spray evaporation equipment used at Evaporation Pond 1 at the HMC site has a wide range of material on the theory and practice of spray evaporation.

An overview of spray evaporation rate considerations, including droplet size, evaporator through put and other factors is at:
http://www.turbomister.com/turbomist-evap-rates.php

An evaporation efficiency conversion chart relating pan evaporation achieved in inches per month to volume of pond circulated through the evaporators is at:
http://www.turbomister.com/PDFs/Efficiency%20conversion%20Table%20Turbomist.pdf - copy attached

A technical paper addressing evaporation theory and practice including consideration of spray fallback factor in spray evaporation rate evaluation is at:
http://www3.interscience.wiley.com/journal/112475413/abstract?CRETRY=1&SRETRY=0 - copy attached

Gregory P. Flach, Frank C. Sappington, and Kenneth L. Dixon, "Field Performance of a Fan-Driven Spray Evaporator", REMEDIATION, Spring 2006

ABSTRACT
"An emerging evaporation technology uses a powerful axial fan and high-pressure spray nozzles to propel a fine mist into the atmosphere at high air and water flow rates. Commercial units have been deployed at several locations in North America and worldwide since the mid-1990s, typically in arid or semiarid climates. A commercial spray evaporator was field tested at the U.S. Department of Energy's Savannah River Site in South Carolina to develop quantitative performance data under relatively humid conditions. A semi-empirical correlation was developed from eight tests from March through August 2003. For a spray rate of 250 L/min (66 gpm) and continuous year-round operation at the Savannah River Site, the predicted average evaporation rate is 48 L/min (13 gpm)." © 2006 Washington Savannah River Company*

CONVERSION TABLE FROM NET PAN EVAPORATION TO TURBOMIST EFFICIENCY ESTIMATES FOR THE TURBOMIST S30P EVAPORATOR

This chart is indicated in inches per month. If you have annual pan evaporation in feet, convert to inches
And divide the total by 12 months to determine the average pan evaporation rate to use below.

Net Pan evaporation (Inches / month) Inches	Percentage of Volume Pumped aloft	Net Pan evaporation (Inches / month) Inches	Percentage of volume Pumped aloft
1.5	20%	9.5	45%
1.75	24%	10	46%
2	27%	10.5	47%
2.25	28%	11	48%
2.5	29%	11.5	49%
3	30%	12	50%
3.25	31%	12.5	51%
3.5	32%	13	52%
3.75	33%	13.5	53%
4	34%	14	54%
4.5	35%	14.5	55%
5	36%	15	56%
5.5	37%	15.5	57%
6	38%	16	58%
6.5	39%	16.5	59%
7	40%	17	60%
7.5	41%	17.5	61%
8	42%	18	62%
8.5	43%	18.5	63%
9	44%	19	64%

This conversion chart is the property of Slimline Manufacturing Ltd an is intended to give our evaporator custom base a conservative estimate of what our S30P evaporator models will do at their site, based upon the net pan evaporation provided.

Field Performance of a Fan-Driven Spray Evaporator

Gregory P. Flach

Frank C. Sappington

Kenneth L. Dixon

*An emerging evaporation technology uses a powerful axial fan and high-pressure spray nozzles to propel a fine mist into the atmosphere at high air and water flow rates. Commercial units have been deployed at several locations in North America and worldwide since the mid-1990s, typically in arid or semiarid climates. A commercial spray evaporator was field tested at the U.S. Department of Energy's Savannah River Site in South Carolina to develop quantitative performance data under relatively humid conditions. A semiempirical correlation was developed from eight tests from March through August 2003. For a spray rate of 250 L/min (66 gpm) and continuous year-round operation at the Savannah River Site, the predicted average evaporation rate is 48 L/min (13 gpm). © 2006 Washington Savannah River Company**

INTRODUCTION

Evaporation provides one mechanism for reducing the volume of wastewater, a common component of an overall wastewater management strategy. Example applications include mining, distillation and textile plants, animal waste disposal, phosphate fertilizer production, and landfill management. Evaporation also has application to groundwater remediation. For example, the Savannah River Site (SRS) is using phytoremediation to reduce the discharge of tritiated groundwater to a stream (Blount et al., 2002). The remediation project involves capturing a tritium (H-3) plume in a man-made pond located at the seepline, and spray-irrigating the collected water over an upgradient mixed pine and deciduous forest. Enhanced evapotranspiration can significantly reduce the net flux of tritium discharging to surface water (Blount et al., 2002). However, evapotranspiration demand is minimal during winter months, and heavy precipitation in any season significantly increases influx to the collection pond due to surface runoff. Under these circumstances, the net influx can exceed the holding capacity of the pond, causing overflow. Thus, a supplemental technology, such as spray evaporation, was desired to remove excess water from the collection pond during winter and wet periods.

An emerging evaporation technology uses a powerful axial fan and high-pressure spray nozzles to propel a fine mist into the atmosphere at high air and water flow rates. Commercial examples include the Slimline Manufacturing Ltd. Turbo-mist (http://www.turbomist.com/) and SMI® Super Polecat evaporators (http://www.evapor.com/). Such evaporators rely on the sensible heat that can be extracted from unsaturated (< 100 percent humidity) air to drive evaporation. Incoming "dry" air is brought into contact with the spray field through a combination of the mechanical fan and natural wind, and simulta-

Published online in Wiley Interscience (www.interscience.wiley.com). DOI: 10.1002/rem.20083

neously cooled and humidified through evaporation. Because the energy for evaporation comes from a natural source, the overall cost is relatively low.

Field performance of these evaporators is affected by a number of factors, including the flow rate, temperature, and humidity of the air contacting the spray field, and the spatial distribution, suspension time, and size of spray droplets. Hot, dry, and windy conditions are most favorable to spray evaporation, and units have been commercially deployed at several locations in North America and worldwide since the mid-1990s, typically in arid or semiarid climates. Although anecdotal information and limited field measurements (Ferguson, 1999) suggest the technology is effective, at least in arid climates, quantitative performance data under more humid conditions are not available. Such data were needed to evaluate the technology for application at the SRS tritium phytoremediation site.

When unsaturated air is brought into contact with liquid water, with no heat transfer to or from the overall system, liquid evaporates and air is cooled until thermodynamic equilibrium is reached.

The purpose of this technical note is to provide evaporator performance data for Southeast U.S. climate conditions, and to present a semiempirical correlation for predicting evaporation near the range of conditions tested. The field data were acquired at the U.S. Department of Energy's Savannah River Site near Aiken, South Carolina, from late March through mid-August 2003. The specific system tested is the Slimline Turbomist evaporator.

EVAPORATION PRINCIPLES

When unsaturated air is brought into contact with liquid water, with no heat transfer to or from the overall system, liquid evaporates and air is cooled until thermodynamic equilibrium is reached (100 percent humidity). Such a process is termed adiabatic saturation and is the principle behind swamp coolers used for residential cooling in the Southwest United States and agricultural cooling (e.g., poultry houses). The energy required to vaporize liquid water (latent heat of vaporization) is extracted from unsaturated air through cooling (sensible heat). The amount of cooling as a function of the temperature and relative humidity of the incoming air stream can be determined through application of the first law of thermodynamics, which states that enthalpy is conserved in a open system. With minor approximation, the adiabatic saturation process can be described by:

$$h^*_{in} = (h_a + \gamma h_m)_{in} + (h_a + \gamma h_w)_{out} + h^*_{out} \quad (1)$$

where h^* = enthalpy of moist air per unit mass of dry air, h_a = enthalpy of dry air, γ = specific humidity or humidity ratio, and h_w = enthalpy of water vapor (Reynolds and Perkins, 1977). The thermodynamic properties of moist air can be readily computed from an American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) handbook (e.g., ASHRAE, 1985) or equivalent source.

As an example calculation, the annual average temperature and relative humidity at the Savannah River Site are 18°C (65°F) and 68 percent, respectively (Hunter & Tatum, 1997). For these conditions, the evaporative cooling achieved when the incoming air stream is saturated is 3.7°C (6.6°F). Exhibit 1 shows contours of constant evaporative cooling degrees resulting from various combinations of temperature and relative humidity. The dashed box defines an approximate envelope of likely weather conditions at the Savannah River Site.

  Remediation DOI: 10.1002.rem

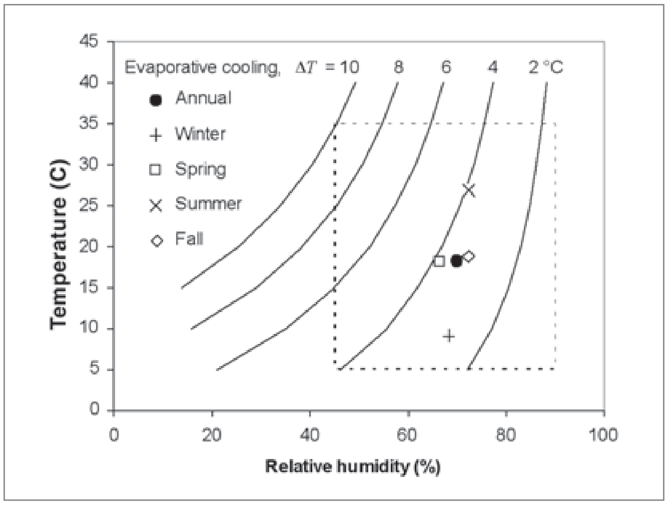


Exhibit 1. Evaporative cooling potential as a function of temperature and relative humidity

Spray evaporation under atmospheric conditions is expected to be proportional to the cooling and evaporation amounts computed under adiabatic saturation conditions. For evaporation to be sustained, air (and water) must be continuously supplied to replenish the system. An energy balance expanding on Eq. (1) indicates that evaporation of liquid water into unsaturated air is proportional to the mass flow rate of air delivered to the system. For atmospheric spray evaporation, fresh air is delivered to the spray field through natural winds. Thus, the spray evaporation rate is also expected to be proportional to local wind speed. The overall dimensions of the spray field, and the distribution, suspension time, and size of spray droplets within, are also expected to affect the evaporation rate.

EXPERIMENT DESIGN AND SETUP

In many evaporator applications, water is drawn from a holding pond (e.g., mine tailings) and sprayed into the air. Droplets not evaporated fall back into the pond. At the Savannah River Site, deployment over dry land was under consideration, leading into field testing. For this situation, high evaporation with little or no fallback was considered to be optimal. Therefore, field testing focused on reduced spray rates (20 to 150 L/min) and smaller droplet sizes compared to that produced by the vendor's default spray nozzle configuration (~250 L/min). Ultimately, the evaporator was deployed at the phytoremediation collection pond, for which fallback was not a concern.

To measure evaporator performance for a particular nozzle configuration and weather condition, specialized collection devices were deployed on a grid to measure spray fallback. The evaporation rate was then computed as the spray rate minus the fallback rate. The surveyed grid system is depicted in Exhibit 2, along with an example fallback pattern. A 6.1-m (20-ft) square spacing was chosen near the origin of the grid where the spray evaporator was located. Collection devices were deployed at a variety of grid locations to handle particular weather conditions—primarily, wind speed and direction. To handle a wide range of potential fallback amounts over the duration of a field

 Remediation DOI: 10.1002.rem

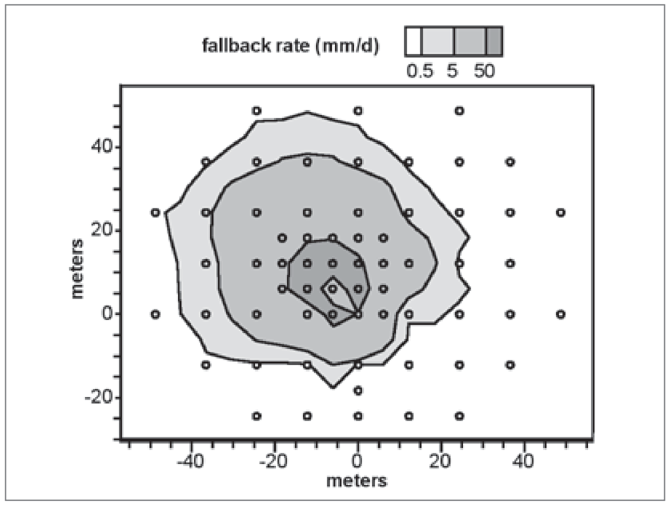


Exhibit 2. Grid system defining placement of spray fallback collection devices, and an example fallback pattern

test, both rain gauges and absorbent pads were used. For each absorbent pad, fallback was determined from the area, and dry (pre-test) and wet (post-test) weights of the pad.

FIELD TESTING AND DATA

Eight field tests were conducted between March and August 2003 (Flach et al., 2003). Comparison of the fallback measurements from the absorbent pads and rain gauges from all tests indicated that the pads are capable of reliably retaining fallback amounts up to approximately 5 mm (0.2 in) of water, while at least 5 mm (0.2 in) is needed with a rain gauge to avoid readings that are biased low. Thus, if a rain gauge reading exceeded 5 mm at an individual grid location, that value was adopted as the fallback amount. Otherwise, the absorbent pad measurement was selected. For each test, a map of spray fallback was created by interpolating the point data from the preferred collection device at each grid location onto a regular 6.1 m (20 ft) × 6.1 m (20 ft) grid using a kriging interpolation algorithm (Isaaks & Srivastava, 1989). Numerical integration of the kriged surface produced the total amount of spray fallback for a given test.

Exhibit 3 summarizes the evaporator configuration, average weather conditions, and spray fallback for each field test. Because testing was conducted from March through August, periods of rainfall were avoided, and daytime testing was preferred for logistical reasons, most tests were conducted at relatively warm temperatures and moderate humidity. An exception was the 16-hour overnight test beginning at 4:21 P.M. on March 31 and ending at 8:58 A.M. on April 1, for which the average conditions were 3.5°C (38.3°F), 72% relative humidity, and 0.85 m/s (1.9 mph) wind speed. These conditions were unfavorable for evaporation, and the evaporation rate was low.

DATA CORRELATION

Because the collection of test data summarized in Exhibit 3 only defines evaporator performance under certain specific conditions, a model capable of predicting evapora-

  Remediation DOI: 10.1002.rem

	Nozzle configuration					Weather conditions		
Test date	No.	Cores	Orifices	Spray rate (L/min)	Evap. rate (L/min)	Temp. (°C)	Rel. hum. (%)	Wind speed (m/s)
03/31/03	30	25	D2	23	6.9	4	69	1.3
04/29/03	30	25	D2	23	20	25	52	2.1
05/01/03	30	25	D5	59	25	26	56	3.1
05/14/03	30	25	D5	63	22	22	46	0.9
06/25/03	30	25	D5	61	31	31	41	1.6
06/26/03	27	45	D6	96	50	31	46	2.2
07/24/03	27	45	D6	99	43	29	56	2.0
08/11/03	30	45	D8	148	53	29	64	2.9

Exhibit 3. Summary of evaporator field testing results

tion rates under more arbitrary conditions is desirable. Following the previously stated expectation that the evaporation rate is largely proportional to the evaporative cooling potential based on adiabatic saturation and wind speed, the dimensional evaporation data are first normalized as

$$E' = \frac{E}{a \cdot \Delta T \cdot V} \tag{2}$$

where E' = normalized evaporation rate, E = evaporation rate, a = empirical constant, ΔT = evaporative cooling, and V = wind speed.

Similarly, the spray rate is normalized as

$$Q' = \frac{Q}{a \cdot \Delta T \cdot V} \tag{3}$$

where Q' = normalized spray rate, Q = spray rate, a = empirical constant, ΔT = evaporative cooling, and V = wind speed.

The evaporation rate is zero when the spray rate is zero. The field data suggest the evaporation rate increases in proportion to spray rate initially but levels off at higher spray rates. A nondimensional empirical function capturing this qualitative behavior is

$$E' = \frac{1}{1 + \frac{b}{Q'}} \tag{4}$$

where E' = normalized evaporation rate, b = empirical constant, and Q' = normalized spray rate. The limiting behavior of Eq. (4) is $E' \rightarrow 0$ as $Q' \rightarrow 0$, and $E' \rightarrow 1$ as $Q' \rightarrow \infty$. In terms of dimensional parameters, Eq. (4) is equivalent to the semiempirical model:

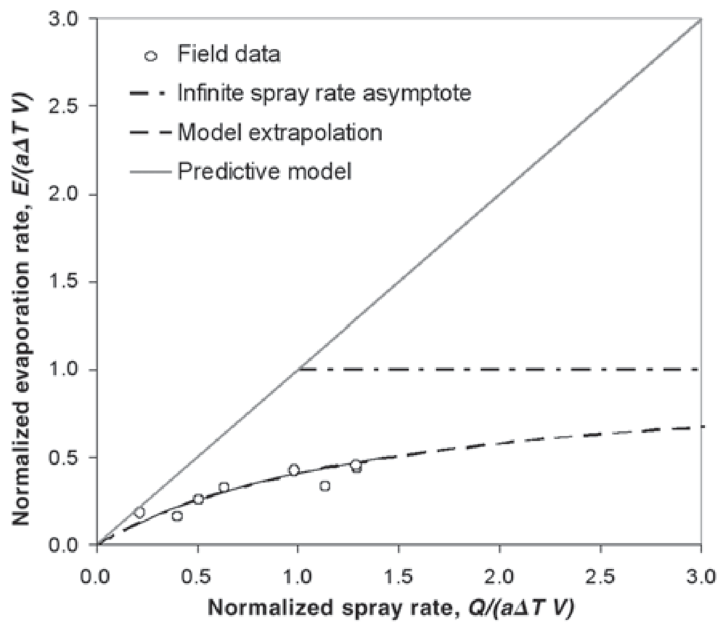


Exhibit 4. Normalized evaporation and spray rates

$$E = \frac{1}{\frac{1}{a \cdot \Delta T \cdot V} + \frac{b}{Q}} \tag{5}$$

with limits of $E \rightarrow 0$ as $Q \rightarrow 0$, and $E \rightarrow a \cdot \Delta T \cdot V$ as $Q \rightarrow \infty$. Optimal values for the empirical constants a and b were determined using least-squares parameter fitting, with the result of $a = 1.24 \times 10^{-4} m^2/°C$ (0.49 gpm/°F – mph) and $b = 1.45$(unitless). Normalized evaporation rate is plotted against normalized spray rate in Exhibit 4. The model is observed to fit the field data reasonably well.

While the functional form given by Eq. (5) incorporates two factors influencing evaporation, other important parameters (droplet size, residence time, etc.) are not explicitly considered. The latter influences are implicitly embedded in the empirical constants a and b. Furthermore, limited field data were available to define optimal values and test the robustness of the selected correlation. Thus, the predictive model is applicable to the particular commercial system and environmental conditions tested. Extrapolation to other evaporator models and weather conditions should be done with caution.

The nondimensional predictive model defined by Eq. (4) can be translated into the equivalent dimensional form given by Eq. (5) for specific weather conditions (i.e., values of ΔT and V). For the default spray rate of 250 L/min (66 gpm) and continuous year-round operation at the Savannah River Site ($\Delta T = 3.7°C$, $V = 2.4$ m/s,), the predicted average evaporation rate is 48 L/min (13 gpm).

 Remediation DOI: 10.1002.rem

COST ANALYSIS

During field experimentation at the Savannah River Site, all power required to operate the evaporator (axial fan and water pump) was supplied through a single portable diesel generator. Power usage varied little during and between tests, and averaged 30 kW. Electricity costs commercial users in the Southeast United States approximately $0.09 per kW-hr. For the projected annual average evaporation rate of 13 gpm, the projected treatment cost is $3.50 per 1,000 gallons of water evaporated.

ACKNOWLEDGMENTS

The work described in this technical note was performed at the Savannah River National Laboratory by Westinghouse Savannah River Company LLC for the U.S. Department of Energy under Contract No. DE-AC09-96SR18500. The authors are grateful to these institutions for permission to publish their findings and for the support of Phil Prater, DOE Project Team Lead. We also thank colleagues Susan Bell, John Bennett, Gerald Blount, and Mo Kasraii for critical program support and technical assistance.

NOMENCLATURE

a, b = empirical constants
h^* = enthalpy of moist air per unit mass of dry air
h_a = enthalpy of dry air
h_w = enthalpy of water vapor
E = evaporation rate
E' = normalized evaporation rate
Q = spray rate
Q' = normalized spray rate
V = wind speed
ΔT = evaporative cooling potential based on temperature and relative humidity
γ = specific humidity or humidity ratio

REFERENCES

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). (1985). ASHRAE handbook: 1985 fundamentals. Atlanta, GA: Author.

Blount, G. C., Caldwell, C. C., Cardoso-Neto, J. E., Conner, K. R., Jannik, G. T., Murphy Jr., C. E., et al. (2002). The use of natural systems to remediate groundwater: Department of Energy experience at the Savannah River Site. Remediation, 12(3), 43–61.

Ferguson, R. B. (1999). Management of tailings pond water at the Kettle River Operation. CIM Bulletin, 92(1029), 67–69.

Flach, G. P., Sappington, F. G., & Dixon, K. L. (2003). Field performance of a Slimline Turbomist evaporator under Southeastern U. S. climate conditions (U). WSRC-RP-2003-00429. Aiken, SC: Westinghouse Savannah River Company. Retrieved October 7, 2005, from http://sti.srs.gov/fulltext/rp2003429/rp2003429.pdf

Hunter, C. H., & Tatum, C. P., (1997). Meteorological annual report for 1996 (U). WSRC-TR-97-0214. Aiken, SC: Westinghouse Savannah River Company. Retrieved October 7, 2005, from http://www.osti.gov/dublincore/ecd/servlets/purl/574238-oiySQz/webviewable/574238.pdf

Isaaks, E. H., & Srivastava, R. M. (1989). An introduction to applied geostatistics. Oxford, UK: Oxford University Press.

Reynolds, W. C., & Perkins, H. C. (1977). Engineering thermodynamics. New York: McGraw-Hill.

Gregory P. Flach, PhD, P.E., is a fellow engineer at the Savannah River National Laboratory (SRNL), where he has worked the past 17 years on a variety of environmental and nuclear engineering topics. He currently specializes in mathematical analysis and numerical simulation of porous media transport.

Frank C. Sappington, retired principal engineer at the Savannah River National Laboratory, has 22 years of civil engineering experience. At SRNL, he developed, deployed, and tested new groundwater remediation technologies, horizontal and vertical barrier systems, and groundwater extraction systems. His BS degree in civil engineering is from the Southern Polytechnic State University.

Kenneth L. Dixon, P.E., is a principal engineer at the Savannah River National Laboratory, where he has worked the past 14 years on a variety of environmental engineering projects. He specializes in pilot-scale testing of innovative remedial technologies and numerical simulation of contaminant transport in the vadose zone.

 Remediation DOI: 10.1002.rem

Technical Assistance Services for Communities
Contract No.: EP-W-07-059
TASC WA No.: R6-TASC-002
Technical Directive No.: R6-Homestake Mining-02

Comments on Air Monitoring and Radon Issues Raised in the U.S. Army Corps of Engineers' Draft Remediation System Evaluation (Supplement) for the Homestake Mining Company (Grants) Superfund Site, New Mexico

May 6, 2010

1.0 Introduction

This document provides the Bluewater Valley Downstream Alliance (BVDA) with comments on air monitoring and radon issues raised in the U.S. Army Corps of Engineers' "Draft Remediation System Evaluation (Supplement) for the Homestake Mining Company (Grants) Superfund Site, New Mexico," a February 2010 draft document prepared by the U.S. Army Corps of Engineers' (USACE) Environmental and Munitions Center of Expertise for the U.S. Environmental Protection Agency (EPA), Region 6.

The USACE Draft Remediation System Evaluation (Supplement), hereinafter referred to as the "DRSE Report," provides a concise review of the air monitoring system at the Homestake Mining Company (HMC) site, with an appropriate focus on radon emissions. The DRSE Report identifies several shortcomings in the monitoring system that could affect whether HMC can demonstrate compliance with the U.S. Nuclear Regulatory Commission (NRC)'s 100-millirem-per year (mrem/y) public dose limit. The DRSE Report's findings track closely with those of the TASC Report No. R6-Homestake Mining-01 ("TASC Report," November 18, 2009), which showed how doses could exceed the limit if a lower radon background value and higher radon-radon progeny equilibrium factor were used in calculations of the Total Effective Dose Equivalent (TEDE) (TASC, 2009; pp. 15-18, Appendix B). The RSE Team recommends changes in the monitoring system to better define background radon, measure radon progeny to develop a site-specific equilibrium factor, improve radon detection around tailings piles and effluent ponds, and better understand site and local meteorology. NRC and EPA should review the findings of both recent reports and consider developing a regulatory strategy to implement the recommended changes in the HMC air monitoring program.

What the DRSE Report lacks with respect to air monitoring issues is a sense of urgency to address the potential public health impacts of persistently high levels of radon measured at monitoring stations located closest to homes in the communities located south and southwest of the HMC site. The TASC Report (pp. 15-16) noted that some of the highest ambient levels of radon recorded anywhere around Homestake's property in 2008 were at the two nearest-residence monitor stations, HMC #4 and HMC #5. An analysis of 10 years of perimeter radon monitoring, presented later in these comments, shows that these two stations have had the highest average annual radon concentrations of *any* of Homestake's eight monitoring stations, and that the levels are significantly higher than those recorded at the HMC site's background monitor location, HMC #16. Like the DRSE Report, the TASC Report questioned the appropriateness of HMC #16 serving as the sole background monitor station.

No outdoor or indoor radon monitoring has been conducted outside of HMC's property boundary since 1987-1988, when the Homestake Subdivision Radon Study detected average annual "corrected" radon levels that were four to nine times greater than background (EPA 1989). In recent sworn testimony, Bluewater Valley Downstream Alliance (BVDA) members raised concerns about the potential health impacts of high radon levels and requested that a formal health study be conducted in the community (NMED Secretary, 2010; testimony of Arthur Gebeau, pp. 268-270, and testimony of Candace Head-Dylla, 281-282). The comments that follow supplement and expand on the issues addressed in both the TASC Report and the DRSE Report to provide all stakeholders, including BVDA members, with a more complete knowledge of historic and recent ambient radon levels, an increased understanding of the range of sources of radon, and an appreciation of the potentially significant health risks associated with chronic exposure to radon at the levels observed in the community.

2.0 Review of Historic and Recent Radon Levels

2.1 Documentation. Six major studies of air monitoring for ambient radon in the region surrounding the HMC site and in the residential areas near the plant were identified and reviewed for these comments. The studies span 39 years, from 1972 to 2009, and are annotated briefly in **Table 1**. Each of the studies used common radon detection equipment and sampling techniques, and conducted calibration tests against sources having known concentrations of radon. While all sampling techniques have some level of measurement and analytical error, and monitoring devices and methods have improved over time, there is no reason to believe that the results of these studies are not comparable for the purpose of gaining a broad understanding of trends in radon levels in the Grants Mineral Belt generally and in the area of the HMC site over the past four decades.

2.2 Data Extraction and Summaries. Ambient radon levels reported in these studies and data sets were extracted and are summarized in **Table 2**. The NMEI study (1974) of radon in the Village of San Mateo was conducted to determine baseline environmental levels prior to the opening of the Mt. Taylor Uranium Mine. No non-background, or mining-influenced, sites were selected for assessment. The 1975 EPA study (Eadie et al., 1976) and 1978-1980 NMEID study (Buhl et al., 1985) included measurements at both background and non-background monitoring sites. The background sites were located in both nearby communities (e.g., Bluewater Lake and the Village of San Mateo) and communities farther away (e.g., the Town of Crownpoint) where no uranium mining or milling had occurred previously. Non-background monitors were set up in active uranium mining and milling areas in Ambrosia Lake, Milan and Bluewater village.

The 1983-1984 NMEID radiological assessment (Millard and Baggett, 1984) and the 1987-1988 Homestake Subdivisions Radon Study (HMC 1989; EPA 1989) were conducted to assess radon levels in Broadview Acres, Murray Acres and Pleasant Valley Estates, the residential areas that bordered the HMC site on the south and southwest at that time. The NMEID study designated two of seven monitor locations as "background" (both were located 10 to 20 miles outside of the area surrounding HMC and in opposite directions), while none of the monitoring locations in the Homestake Subdivisions study was designated "background" or "non-background." Accordingly, the overall mean "corrected" radon concentration of 1.9 picoCuries per liter-air (pCi/l) was not designed background or non-background in **Table 2**. As discussed in Section 2.3, radon levels reported in the two subdivision studies are grouped with concentrations at designated background monitoring sites for analysis of time trends.

The last large data set, also summarized in **Table 2,** contains the results of 10 years of fenceline monitoring conducted by HMC and reported semi-annually to NRC and the New Mexico Environment Department (NMED). The data were extracted from the company's semi-annual environmental monitoring reports (SAEMRs) and compiled in an Excel spreadsheet. They are tabulated in **Table 3a**, and discussed in more detail in Section 2.5. Locations of seven fenceline monitors and one background monitor, HMC #16, are shown in **Figure 1**, a map prepared by HMC and presented as an exhibit in the January 12-13, 2010 public hearing on DP-725 (Baker 2010b). (See, also, DRSE Report, Figure 21[1], p. 39.)

Results for monitor station HMC #16 are included in the background column of **Table 2** because this station, which is located about 2.75 miles northwest of the Large Tailings Pile (LTP), is designated as the background monitoring site for the facility. Results for HMC #4 and HMC #5, designated as "nearest-residence" monitoring sites, are shown in the "non-background" column of **Table 2** to differentiate them from HMC #16, the designated background monitor. Radon levels for monitors HMC #1, HMC #2, HMC #3, HMC #6 and HMC #7 were pooled into one average concentration and placed in the "non-background" column because these stations are sited at locations predicted to have the highest concentrations of airborne particulates (DRSE Report Supplement, p. 37).

Results of air monitoring conducted by HMC at its perimeter monitor stations in the 1980s and 1990s were not reviewed or reported here because they are not available from the NRC's ADAMS electronic document retrieval system. SAEMRs and other reports containing radon levels for that period are likely housed in NRC's document repository in paper copies only. To close the 20-year gap in radon monitoring data, HMC should compile, summarize and report all fenceline radiological monitoring data from the 1980s and 1990s.

2.3 Analyses of the Historic Radon Data. Descriptive statistics for the historic radon data were derived from the six studies listed in **Table 1** or were generated anew using statistical applications contained in Microsoft Excel. Means of average annual radon levels at background monitoring stations and radon levels recorded at monitors in or next to the residential areas were used to construct a plot of radon levels over time. This plot is shown in **Figure 2**. Standard deviations reported by the studies' authors or calculated using Excel spreadsheet software are depicted as error bars around mean values.

The plot in **Figure 2** appears to depict two groups of data: (i) concentrations at background sites ranging from 0.19 pCi/l to 0.71 pCi/l during the period 1972 to 1983; and (ii) average annual radon levels in the two residential studies (1983-84 and 1987-88), at HMC's background monitor (HMC #16) and at the nearest-residence monitor (HMC #4) between 1999 and 2009. The levels in the more recent group were significantly higher than those in the earlier group. A trendline applied to the data suggests an increasing trend in radon levels over time.[2]

---

[1] DRSE Figure 21 is a copy of a map that HMC has used many reports for at least the last decade, but which is now known to be incorrect with respect to the location of HMC #16. The more recent figure that is reproduced as Figure 1 in this report not only is stated to be accurate with respect to the location of HMC #16 (see, testimony of Kenneth L. Baker, January 12, 2010 (HMC, 2010; Exhibit 36B)), but is also more legible.

[2] Not depicted on **Figure 2** is an average Rn-222 concentration of 2.1 pCi/l was detected at Monitor #803 in the November 1975 EPA radon study. According to the EPA report of the study (Eadie et al., 1976, pp. 8-10), this monitor was located 1.0 miles south-southwest of the tailings pile in or next to Broadview Acres. The report categorized Monitor #803 as a non-background monitoring site, and included in one of the data tables the following

Several factors may explain the apparent differences in radon levels between the two periods. At the time of the earliest studies, more than 60 uranium mines and three uranium mills were operating in the region bounded by Interstate 40 on the south, the Mt. Taylor volcanic fields and highlands on the east, and uplifted sedimentary sequences on the west and north (NMMMD, 2009). The investigators carefully selected sites for determination of background, ranging from the Village of San Mateo on the northwest flank of Mt. Taylor to the Town of Thoreau 20 miles west of the area, and the Town of Crownpoint, 35 miles northwest of the Ambrosia Lake mining district. Even then, Buhl and colleagues (1985) reported that some of the monitoring locations designated as background may have been influenced by mining and milling releases. The authors stated that this finding explains why the average annual background concentrations of 0.57 pCi/l (1979) and 0.50 pCi/l (1980) were two to three times higher than background levels at other locations not experiencing uranium mining. The high levels recorded in the residential areas in the 1980s and the high levels reported at the nearest residence monitor (HMC #4) indicate a source or sources of radon not found in the other communities.

The data in **Table 2** and **Figure 2** clearly show that outdoor radon levels approaching or exceeding 2 pCi/l have been detected in the residential areas next to the HMC site since at least the early 1980s. An overall increase above background of between 1.2 pCi/l and 1.7 pCi/l Rn-222 has been observed in or near the residential area over this time. At times, the radon levels in the neighborhoods next to the HMC site have been more than 10 times higher than the lowest background concentrations. The outdoor levels near the residences on average are five to six times higher than the average U.S. level (0.4 pCi/l) reported by EPA (2010). The persistence of average annual radon levels of 1.8 pCi/l and 1.63 pCi/l at the two nearest-residence monitors over the last 10 years indicates that the problem is not going away.

2.4 Homestake Subdivisions Radon Study and EPA 1989 No-Action Record of Decision. The Homestake Subdivisions Radon Study merits further discussion for two reasons. First, the study documented high outdoor and indoor radon levels in the residential area through an extensive sampling program. Second, the study resulted in a finding by EPA Region 6 that the high ambient and indoor levels could not be correlated with emissions from HMC's operations. As a result, EPA implemented a "No-Action Alternative" that did not require HMC to take any remedial actions to lessen radon levels in the communities (EPA 1989). The Agency's Record of Decision (ROD) recommended that residents living in eight homes having indoor radon levels at or exceeding the EPA "action level" of 4.0 pCi/l take one, two or three actions to reduce indoor radon levels: (i) increase ventilation of crawl space, (ii) install high-efficiency, forced-air heating, and (iii) seal cracks and openings in floors (EPA 1989, Table 8). The extent to which these recommended repairs were made by the particular eight homeowners is not known.

As shown in **Table 2**, the average outdoor radon level of the 28 monitors in the community was 1.9 ± 0.4 pCi/l, bounded by extremes of 1.2 pCi/l to 2.7 pCi/l. These were "corrected" values that were reduced from "measured" radon levels by subtracting a calibration factor derived from exposing the Track-Etch detectors to a known quantity of radon. The outdoor calibration factors

---

remark: "Elevated radon due to milling?" (Eadie et al., 1976, Table 3). The radon level for this monitor is not placed in **Figure 2** because the monitoring location was not categorized as a background site, but deemed a site possibly influenced by releases from the HMC uranium mill. If this average radon level were to be included in **Figure 2**, it would appear as a outlier nearly three times greater than the average radon level of the five background monitors sampled in the EPA/Eadie study.

ranged from 0.47 pCi/l in the second quarter of the study to 0.95 pCi/l-air in the fifth quarter (EPA 1989, p.7). The average measured outdoor radon concentration was 5.2 ± 1.53 pCi/l on a range of 2.8 pCi/l to 8.2 pCi/l. As discussed in Section 4 below, these levels, when coupled with an average corrected indoor radon concentration of 2.7 pCi/l, present lifetime lung cancer risks on the order of 7 in 1,000.

2.5 Trends in Radon Levels at HMC Monitoring Stations. The RSE Team noted (DRSE Report, p. 37) that HMC #6, the perimeter monitor station that is located one mile west of the LTP and is designated as the background site for radioactive particulates, had a radon concentration of 2.8 pCi/l in the second half of 2008 — the single highest radon level recorded at any of the monitors since 1999. However, a close examination of 10 years of radon levels at all eight monitors (**Table 3a**) shows that HMC #6 had the fourth *lowest* annual average radon concentration. As noted above, the two nearest-residence monitors, HMC #4 and HMC #5, had the highest average annual radon levels over the 10-year sampling period, as shown in **Figure 3**. The designated background monitor, HMC #16, did not have the lowest annual radon level; HMC #3, which is located 0.8 miles east of the LTP, had the lowest annual radon level. The nearest-residence monitors had the highest annual average radon levels, and *all eight monitors* had average radon levels greater than 0.71 pCi/l, which was the highest average concentration of the background levels recorded between 1972 and 1983 (**Table 2** and **Figure 2**).

The results of a statistical analysis to test whether radon levels recorded at the two nearest-residence monitors, HMC #4 and HMC #5, are significantly higher than levels recorded at the background station, HMC #16, are shown in **Table 3b**. A t-Test for two samples (assuming unequal variance) was performed on the data set using the Excel Data Analysis function and assuming a normal distribution of the data.[3] Only two monitors, HMC #3, located 0.8 miles east of the LTP, and HMC #7, located within 1,000 feet of the Small Tailings Pile (STP), had radon levels that were no different than those levels recorded at HMC #16. Radon levels at the rest of the monitors were all significantly different than those levels measured at HMC #16. HMC #4 and HMC #5, the two nearest-residence monitors, had average annual radon levels significantly higher than those at HMC #16, with p values of 0.0000001 and 0.0002, respectively. This means that the probability that the average levels in the nearest-residence monitors were different than the average level in HMC #16 by chance only is infinitesimally small.

These analyses suggest that HMC #16 may be sampling a different population of ambient radon gas than all but two of the other perimeter monitors, and perhaps all of them. While the populations may be different, radon concentrations at all of the monitors around the HMC site and at the background site are still far greater than the background levels recorded elsewhere. These analyses validate the TASC Report's concern that HMC #16 may not represent true background radon levels (it is located within 3 miles of abandoned mines located next to Haystack Road), and add support to the RSE Team's recommendation for fresh characterization of background by adding two or three new monitoring stations (DRSE Report, pp. iv, 37, 47).

2.6 Sources of Radon and Other Radioactive Materials. The HMC mill, which opened in 1958 and closed in 1990, was still operating at the time the Subdivision Radon Study was

---

[3] This assumption was based on an examination of the differences between mean and median Rn concentrations shown in **Table 3b**. The largest difference was -0.08 pCi/l in HMC #5, and four of the eight monitors had mean-median differences ranging from -0.02 to 0.01 pCi/l. These small differences mediated against using non-parametric methods for the analysis.

conducted in 1987-88. The mill was decommissioned and demolished between 1993 and 1995, and interim soil covers were placed on the sides of the LTP and STP during that time (DRSE Report Supplement, pp. 3, 38). The top of the LTP has a thin dirt cover, but has not been fully covered in order to accommodate operation of the wells used in the ground-water remediation flushing program.

2.6.1 HMC Waste Management Units. In addition to the LTP and STP, other sources of radioactive emissions from the site include the reverse osmosis effluent treatment plant located at the southwest corner of the LTP and the four existing collection and evaporation ponds located on the south side of the LTP. Evaporation Pond #1 (EP-1) was built on top of the STP in 1990 and is still in operation today. On-site tests conducted for HMC in 2009 determined that the radon flux from EP-1 was 1.13 pCi/m^2-sec, according to a draft report prepared by consultants to HMC (Simonds et al., 2009). Evaporation Pond #2 (EP-2) is sandwiched between EP-1 on the east and the East and West Collection Ponds on the west. Exposed tailings and unwetted berms on the ponds are sources of radon.

2.6.2 Effluent Spraying. Spraying of pond effluent by Homestake to increase evaporation of wastewater generated by the ground-water remediation system may also be a source of radon and radon progeny, as noted in both the November TASC Report (pp. 18-19) and in the DRSE Report (pp. iv, 38). Deposition of precipitates from the high-salinity wastewater onto the berms and sides of EP-1 and EP-2 was documented in photographs taken by Wm. Paul Robinson and appended to Mr. Robinson's testimony in the January 2010 hearing on DP-725 (Robinson, 2010; slides 13, 14, 17, 18; attached hereto as **Appendix A**). No radiochemical or trace-element data for the precipitates have been disclosed, a concern noted in the first Remediation System Evaluation sanctioned by EPA Region 6 (EQM, 2008, p.35). The extent of deposition of precipitates from the spraying is unclear from an examination of uranium and radium-226 concentrations in soils sampled east of EP-1 and State Route 605. Those concentrations are shown in a map of the area provided by Homestake at the January 12-13, 2010 hearing on DP-725 (Baker, 2010c), and included in this report as **Figure 4**. A radium-226 concentration of 9 picoCuries per gram (pCi/g) was detected in the first six inches of soil at sampling location EP-4, and a uranium concentration of 13 milligrams per kilogram dry weight, or parts per million (mg/kg-dw and ppm), was detected in the first six inches of soil at nearby sampling location EP-1. As discussed in Section 2.6.1.2 below, these concentrations are not considered to be within the range of background absent site-specific data to the contrary.

The TASC Report (p. 18) noted that local residents had reported in a letter to NMED in 2008 that sprays were being blown beyond the perimeter of the evaporation ponds. More recently, residents of the adjacent neighborhoods reported observing the effluent spray "drifting" into the community, and provided photographs to document their observations and concerns. (See, NMED Secretary, 2010; testimonies of Jonnie Head, pp. 291-292, Mark Head, pp. 294-295, and John Boomer, pp. 297-299.) The first RSE report concluded that the "completion elimination" of spraying "seems appropriate," given the reports of local residents and "the potential for human health and environmental exposure" (EQM, 2008, p. 48).

DP-725, issued as amended by NMED on April 12, 2010, is conditioned to require HMC to "operate the forced spray system such that the spray remains within the confines of the ponds to the extent practicable" (NMED, 2010, Condition 8, p. 6). The permit also requires HMC to submit to NMED a plan that outlines the specific atmospheric conditions, such as wind speeds and wind directions, under which the sprayers would not be operated or would automatically shut off (*Ibid*.). Neither DP-725 nor SUA-1471, the NRC license for the facility, currently contains specific limitations on sprayer operations.

As soon as possible, Homestake should conduct and submit to NMED, NRC and EPA radiochemical analyses of precipitates deposited by the sprayers on the berms of the evaporation ponds. Data on particulates detected at the seven perimeter air monitors should be analyzed to determine if radionuclide levels are correlated with wind patterns (velocities and directions) and/or spraying events. Minimally, DP-725 and SUA-1471 should be amended to prohibit spraying when weather conditions would cause mists and precipitates to be deposited outside of the perimeters of the ponds. The final RSE report should assess whether, based on existing monitoring data, effluent spraying is protective of public health.

<u>2.6.3 Contaminated Soils</u>. Another source of radon at the HMC site would be contaminated soils. A wide area of contaminated soils located north, northeast and east of the LTP were excavated in 1993-1995 to meet NRC and EPA cleanup standards. Data presented by HMC at the January 2010 public hearing on DP-725 showed 7 ppm uranium and 6 pCi/g radium in soils near the location of HMC #5 (**Figure 4**). These concentrations may or may not be in the range of normal levels for the alluvial soils that cover the San Mateo Creek drainage area around the HMC site. For comparison, uranium levels in undisturbed soils located on non-uraniferous Cretaceous rocks in Church Rock, Coyote Canyon, Nahodishgish and Pinedale chapters of the Navajo Nation ranged from 0.3 ppm to 2.61 ppm, based on nearly 70 sampling points (Shuey et al., 2007; deLemos et al., 2008). Crustal average radium concentrations are widely reported in the published literature to be around 1 pCi/g. The EPA's clean-up standard for soils contaminated by windblown uranium mill tailings is 5 pCi/g radium-226 in the first 15 centimeters of soil, *excluding* background. (See, 40 CFR 192.32.)

<u>2.6.4 Subdivisions Radon Study and 1989 EPA ROD</u>. EPA's 1989 ROD for the Radon Operable Unit listed building materials and soils under homes as possible sources of indoor and outdoor radon (EPA 1989, p. 8). However, the ROD stated that gamma radiation surveys turned up no evidence that radioactive materials were used in home construction. Uranium and radium levels in soils collected from beneath and adjacent to homes with elevated indoor radon levels "were indicative of background levels and provided no evidence that tailings were significant in the soil in the vicinity of these residences" (EPA 1989, p. 9). Despite this finding, the ROD states that "the primary source of indoor radon in homes in the subdivisions is local soil which emits radon gas." Results of the soil monitoring cited to conclude that soil uranium and radium levels "were indicative of background" were not provided in the ROD, and there was no indication given in the ROD that soil-gas experiments were conducted.

<u>2.6.5 Aerial Radiation Surveys, 2009</u>. In fall 2009, contractors to EPA Region 6 conducted aerial gamma radiation surveys in several subregions of the Grants Mineral Belt, including in the vicinity of the HMC site. A draft report containing color maps and orthophotomosaics documenting gamma radiation rates and uranium-in-soil concentrations was released for public comment in January 2010 (EPA 2010a). Images 14, 26, 38 and 53 of the report cover the residential and agricultural areas located south and southwest of the HMC site. The overflights touched the southern half of EP-1 and the edge of EP-2, and these locations are easily discernible on the maps because they have colors representing higher gamma activity levels or higher uranium concentration levels. While precise locations of elevated gamma radiation and uranium cannot be discerned from these maps because of their large scale, the color contours that represent radiation levels do not identify activities or concentrations that would indicate the

presence of an anthropogenic source or sources of radiation and uranium in the residential areas near the HMC site. In fact, some of the images suggest that soils in the residential area exhibit uranium in concentrations within the natural range. Image 38, for instance, shows colors indicating uranium concentrations in soils in the residential areas of less than 4 pCi/g, compared with colors indicating concentrations >9 pCi/g at the edge of the HMC evaporation ponds.

<u>2.6.6 Inventory Needed of All Radon Sources</u>. The *only* source of human-made or technologically enhanced, naturally occurring radioactive materials in the vicinity of the subdivisions is the HMC site, including its crop irrigation plots located northwest and west of Pleasant Valley Estates. All other anthropogenic sources of radon — abandoned uranium mines and closed uranium mills — are located six miles east, six to seven miles north, and four to five miles west of the community, according to the New Mexico Mining and Minerals Division uranium mine database (NMMMD, 2009). As noted in the DRSE Report (p. 42), EPA Region 6 is planning to conduct a new round of environmental sampling in the neighborhoods next to the HMC site later this year in support of a new risk assessment. Minimally, the assessment should include outdoor and indoor radon monitoring, soil surveys for gamma radiation and uranium and radium concentrations, surveys of structures for indications of the use of contaminated materials, an inventory of natural and human-made sources of radioactive materials, and recalculation of radiation doses to the public. An objective of the assessment should be a complete inventory of all sources of radon to further investigate why levels exceeding 1 pCi/l-air have persisted in the neighborhoods next to the HMC site for more than 35 years.

3.0 Air Monitoring Issues and Dose Calculations

3.1 Adjustments in Current Monitoring System. As noted in the Overview of these comments, the principal objective of HMC's air monitoring program is to determine compliance with NRC's 100-mrem/y dose limit to the nearest member of the public exposed to releases of radioactive materials from licensed activities (DRSE Report, Section 7.2.1, p. 36). HMC operates the eight perimeter air monitoring stations to measure airborne concentrations of radon and radioactive particulates of uranium, thorium-230 and radium-226, and direct gamma radiation rates. While the DRSE Report states (p. 37) that the eight monitors meet the minimum requirements of NRC Regulatory Guide 4.14, the report also notes that NRC Regulatory Guide 4.14 requires monitoring for lead-210, which is not presently being done by HMC. HMC should begin monitoring for Pb-210 in particulates immediately or provide an explanation of why it is not required or why HMC is exempt from doing so.

The NRC Regulatory Guide 4.14 (Section 2.1.2) also requires that "[a]ir particulate samples should be collected continuously at…the residence or occupiable structure within 10 kilometers of the site with the highest predicted airborne radionuclide concentration…" As noted previously, no air monitoring for radon or other radionuclides is being conducted outside of HMC's restricted area boundary, with the exception of uranium in soils at the two crop irrigation plots located 1.5 and 2.5 miles west and southwest of the LTP. Absent a specific legal or technical reason not to select a monitoring site *next to a residence*, HMC should consult with BVDA, EPA and NRC to propose and select a suitable monitoring location in Murray Acres or Broadview Acres.

The DRSE Report (p. 37) also points out that HMC furnishes no meteorological data to support its air monitoring program. However, HMC has acknowledged that it maintains an on-site meteorology station from which it gathers data on wind speeds, wind directions, ambient temperature and other atmospheric conditions. In the January 2010 public hearing on DP-725, HMC presented a wind rose diagram that showed the highest frequency of winds moving from the northeast across the tailings piles toward the community to the southwest. (A copy of this diagram is contained in **Figure 5**.) While those "northeasterlies" appear to travel at less velocity than winds coming from the west and southwest, their presence at the HMC site may explain why high radon levels have been observed at monitor stations HMC #4, HMC #5 and HMC #6. As suggested in the DRSE Report (p. 37), the LTP itself may act as a funnel carrying low-lying wind currents toward the community.

HMC should compile and report all previous meteorological data, and commit to including all future meteorological data in its SAEMRs. HMC should also undertake a study of localized wind patterns to determine if the tailings piles or other land features contribute to a channeling of currents into the adjacent community. HMC also should establish a met station in the residential area, perhaps co-located with a new air monitoring station as recommended above. The final RSE Report should include these expanded recommendations.

3.2 Assumptions Influencing Calculation of the TEDE. To demonstrate compliance with the NRC dose limit, HMC calculates the TEDE from all releases of radioactive materials on an annual basis. The calculation and rationale for its assumptions are contained in Attachment 4 of each SAEMR, titled "Annual Effective Dose Equivalent to Individuals of the Public" (HMC, 2000-2009). The dose from radon exposure dominates the TEDE calculation; contributions to the TEDE from particulate emissions and direct gamma rates make up a small portion of the dose. The DRSE Report (pp. iv, 38) questions HMC's use of certain values for two assumptions that significantly influence the TEDE calculation: the residential occupancy factor (OF) and the radon-radon daughter equilibrium factor (EF).

3.2.1 Occupancy Factor (OF). The RSE Team cites NRC staff guidance that requires use of an OF of "unity," or 1.0, because "10 CFR 20.1302 (b) (2) (ii) involves the assumption that an individual is continually present in the area." (See, http://www.nrc.gov/about-nrc/radiation/protects-you/hppos/qa68.html.) HMC cites an NRC technical document (NUREG-5512, p. 6.37) for its use of an OF of 0.75 (HMC, 2000-2009, Attachment 4, p. 1). Notwithstanding the NRC staff technical position, the time and activity patterns of many residents living in the vicinity of the HMC site warrants use of an occupancy factor of 1.0. The character of the surrounding neighborhoods is semi-rural and agricultural. Most local residents engage in outdoor activities related to farming and gardening, tending to livestock, and raising and caring for horses. Whether working indoors or outdoors, they tend to be in the vicinity of their homes most of the time.

3.2.2 Equilibrium Factor (EF). The EF refers to the proportion of radon activity that comes from radon's short-lived decay products, called "progeny" or "daughters." As radon-222 decays after being emitted from a source, its decay progeny takes time to "catch up." Distance and time dictate how rapidly the progeny come into equilibrium with the parent. Eventually, radon will be present in an equal proportion with its progeny; in that case, the radon-radon progeny equilibrium is 100 percent or 1.0.

In every SAEMR submitted to NRC and NMED since at least 2000, HMC has used an EF of 0.2 (20 percent) based on the same rationale:

> "Since the nearest residence is within a few hundred feet of the site perimeter and within 3,500 feet of the major source of radon, the radon daughter equilibrium should be low. We have selected 20 percent radon daughter equilibrium as an estimate for use in the calculations." (HMC, 2000-2009; see, SAEMR dated December 31, 2009, Attachment 1, p. 3; NRC Document No. ML100970422.)

Verifiable and site-specific EFs can be calculated from radon and radon progeny concentrations measured in air. Three of the six radon studies listed in **Table 1** included estimated EFs based on air monitoring data. **Table 4** summarizes the technical bases for these estimates. The estimates in the studies ranged from 28 percent to 73 percent. The 28 percent EF estimated by Millard and Baggett (1984, p. 2) was for the closest residence to the LTP. Indoor and outdoor radon levels exceeding 2.0 pCi/l were observed in and around homes located more than 1.5 miles west and southwest of the closest residence in the 1989 Subdivisions Radon Study (HMC, 1989; USEPA 1989, Tables 1 and 2). The increased travel time and distance from the radon source at HMC to residences in Pleasant Valley and Valle Verde Estates would allow increased in-growth of radon daughters, increasing the EF.

HMC provides no calculations to support its choice of an equilibrium factor of 0.2, and none of the historic studies examined for these comments justify the use of an EF of 20 percent. The 50 percent factor estimated by NMEID staff based on results of the 1978-1980 Radon Study is technically justifiable and more conservative from a public health perspective.

<u>3.2.3 Effects of OF and EF on TEDE Calculations</u>. The November 2009 TASC Report (Table 2, p. 17) demonstrated how selection of an inflated background radon concentration acts to *reduce* the TEDE and facilitate compliance with the 100-mrem/y rule. The TASC Report also showed that a low radon-radon daughter EF also diminishes the final dose calculation (TASC, 2009, Appendix B).

The November 2009 TASC analysis can now be updated to show the effects of overstating background radon levels and underestimating the OF and EF on the TEDE calculation. **Table 5** below presents HMC's 2009 TEDE calculation as the "base case" – a "background" radon level of 1.3 pCi/l, an OF of 0.75 and an EF of 0.2. As the background level is reduced and the OF and EF are increased to 1.0 and 0.5, respectively, the calculated doses exceed the 100-mrem/y limit by up to four times. Even if an inflated background level is retained but higher occupancy and equilibrium factors are used, the TEDE exceeds the 100-mrem/y limit. As suggested by the RSE Team, HMC should reassess all input parameters to the TEDE calculation. NRC staff should review all assumptions and rationales presented by HMC in the annual TEDE calculation provided in the semi-annual environmental monitoring reports.

4.0 Public Health Risks

Radon and its decay products are well-documented radiotoxicants that attack human and animal cells with high linear-energy transfer alpha particles the size of helium nuclei. More than a dozen epidemiological studies of underground uranium miners has demonstrated substantial increased risks of lung cancer and lung cancer mortality from exposure to radon and radon progeny (see, e.g., Samet et al., 1984; Wagoner et al., 1975). These effects have been demonstrated in the largely non-smoking Navajo uranium miner cohort (see, e.g., Gilliland et al., 2000; Roscoe et al., 1995); cigarette smoking has been identified as having a multiplicative effect on incidence and mortality. Studies of uranium miners have been applied to measured levels of radon indoors to generate estimates of the impact of indoor radon on lung cancer incidence and mortality (Samet and Maple, 1998). EPA (2010), for instance, estimates that 14,000 to 21,000 lung cancer cases result from exposure to indoor radon annually in the United States, and that radon ranks second only to cigarette smoking as the leading cause of lung cancer in the United States. The World Health Organization (WHO, 2009) recently recommended a 33 percent decrease in the indoor radon "action level," from 4 pCi/l to 2.7 pCi/l, in recognition of the fact that "there is no known threshold concentration below which radon exposure presents no risk. Even low concentrations of radon can result in a small increase in the risk of lung cancer."

For these reasons, HMC, EPA, NRC and all other stakeholders should be concerned about chronic exposure to levels of radon that have averaged nearly 2 pCi/l in the residential areas near the HMC site since at least the mid-1970s. The lung cancer risk at this level is significant. As shown in **Table 6**, a nonsmoker exposed to 2 pCi/l of radon indoors has a lifetime lung cancer risk of 4 in 1,000, or 1 in 250. A person exposed to 4 pCi/l who is not a smoker has a lifetime lung cancer risk of 7 in 1,000, or 1 in 143. (These cancer risk levels are high compared with the range at which EPA usually regulates carcinogens: from 1 in 1 million chance to 1 in 10,000.) A smoker or a former uranium miner faces even greater risks. To put those numbers into perspective, BVDA members estimate that about 300 people live in the subdivisions that lie in the shadow of the Homestake mill tailings site. (See, slides 23 and 24 of **Appendix A**.) Accordingly, one to two residents could contract lung cancer during their lifetimes from long-term exposure to the levels of outdoor and indoor radon observed in the community.

The final RSE Report should review the public health risks associated with chronic exposure to levels of radon observed in the community. Furthermore, it is advisable for the regulatory agencies to identify sources of funding for health studies, and to engage uninvolved third-party organizations with appropriate credentials to design and implement health studies in the affected community. Facilitation of health studies could be done through the RSE Advisory Committee, which includes BVDA members. This approach would help ensure that all stakeholders have a part in selecting the health study providers.

5.0 Recommendations

All recommendations contained in these comments are consolidated in this section to facilitate their review and consideration.

5.1 Environmental Monitoring.

The DRSE Report should be revised to recommend that —

(i) HMC compile, summarize and report all fenceline radiological air monitoring data from the 1980s and 1990s. These data are expected to be stored in hard copies in the NRC's public document repository.

(ii) Any new air monitoring stations be sited consistent with locations of monitors that had average annual radon concentrations of less than 0.7 pCi/l-air, which is the upper range of average levels reported in previous studies.

(iii) The planned EPA Region 6 risk assessment include outdoor and indoor radon monitoring, soil surveys for gamma radiation and uranium and radium concentrations, surveys of structures to detect the use of contaminated materials, and an inventory of natural and human-made sources of radioactive materials. Monitoring of radon at HMC's fenceline monitoring stations should be done concurrently with air monitoring in the residential areas.

(iv) EPA-6 consider hiring a community member to serve as a liaison between the community and EPA and its contractors during field studies associated with the assessment and at the time results of the risk assessment are presented to the community.

(v) EPA Region 6 review and reconsider the findings, conclusions and recommendations of the 1989 Record of Decision of the Radon Operable Unit in light of the findings of new environmental monitoring conducted as part of the planned risk assessment and by HMC under its routine and expanded monitoring program.

(vi) HMC comply with NRC Regulatory Guide 4.14 and immediately begin monitoring Pb-210 in particulates measured at its eight air monitoring stations.

(vii) HMC establish at least one air monitoring station in the residential area southwest of the site, including consultation with BVDA, EPA and NRC before selecting a suitable residential monitoring location. Consideration should be given to establishing more than one air monitoring station in the residential area to provide an appropriate geographic distribution that takes into account local wind speeds and directions, and possible contributions to radiation releases from HMC's two irrigation plots located west of Valle Verde Estates.

(viii) HMC compile and report all previous meteorological data, and commit to including all future meteorological data in its Semi-annual Environmental Monitoring Reports. The DRSE Report should further recommend that HMC undertake a study of localized wind patterns to determine if the tailings piles or other land features contribute to a channeling of currents into the adjacent community.

(ix) HMC establish a meteorological station in the residential area. The residential air monitoring station recommended in Section 5.1(vii) above could be co-located at a new residential meteorological station. The residential meteorological station should be capable of measuring wind speeds and directions and ambient temperature and pressure.

5.2 Effluent Spraying:

The DRSE Report should be revised to recommend that —

(i) Homestake conduct and submit to NMED, NRC and EPA radiochemical analyses of precipitates deposited by the sprayers on the berms of the evaporation ponds as soon as possible.

(ii) Data on particulates detected at the seven perimeter air monitors be analyzed to determine if radionuclide levels are correlated with wind patterns (velocities and directions) and/or spraying events.

(iii) DP-725 and SUA-1471 be amended to prohibit spraying when weather conditions would cause mists and precipitates to be deposited outside of the perimeters of the ponds.

(iv) An assessment be conducted on whether existing monitoring data are adequate to determine if effluent spraying is protective of public health. If the RSE Team finds that existing monitoring data are not adequate to determine if effluent spraying is protective of pubic health, the final report should identify the scope of a data-gathering program needed to make such a determination.

5.3 Dose Calculations. The DRSE Report should recommend that HMC reassess all input parameters to the calculation of the Total Effective Dose Equivalent (TEDE), including and especially the occupancy factor and the radon-radon daughter equilibrium factor. The DRSE Report should further recommend that the NRC staff review all assumptions and rationales presented by HMC in the annual TEDE calculation provided in the semi-annual environmental monitoring reports.

5.4 Public Health Risks. The DRSE Report should review the public health risks associated with chronic exposure to levels of radon observed in the community. The planned EPA risk assessment should include a summary of historic and current radon levels around the HMC site and in the community, and calculate doses and respiratory risks using those data. All management alternatives to mitigate or eliminate exposures from anthropogenic sources of radiation, heavy metals and other contaminants should be fully and fairly considered.

5.5 Public Health Studies. The DRSE Report should recommend that HMC, EPA, NRC and NMED identify funding for health studies in the communities, and work with BVDA to identify uninvolved third-party organizations with appropriate credentials to design and implement health studies in the affected community. The RSE Advisory Committee, which includes BVDA members, may be an appropriate vehicle in which to begin these discussions to ensure that all stakeholders have a part in identifying funding sources and recommending health study providers.

6.0 TASC Contact Information

E² Inc. Project Manager and Work Assignment Manager
Terrie Boguski, P.E.
913-780-3328
tboguski@e2inc.com

Wm. Paul Robinson and Chris Shuey, TASC Subcontractors
Southwest Research and Information Center
P.O. Box 4524, Albuquerque, NM USA 87196
505-262-1862
sricpaul@earthlink.net
sric.chris@earthlink.net

E² Inc. Program Manager
Michael Hancox
434-975-6700, ext 2
mhancox@e2inc.com

E² Inc. Director of Finance and Contracts
Briana Branham
434-975-6700, ext 3
bbranham@e2inc.com

E² Inc. TASC Quality Control Monitor
Paul Nadeau
603-624-0449
pnadeau@e2inc.com

7.0 References

Buhl, et al., 1985. Thomas Buhl, Jere Millard, David Baggett, Sue Trevathan. Radon and Radon Decay Product Concentrations in New Mexico's Uranium Mining and Milling District. Santa Fe: New Mexico Environmental Improvement Division; March.

Baker, 2010c. Exhibit HMC 36D, "Soil Assessment Sample Results Uranium and Ra-226," attached to testimony of Kenneth L. Baker, in the Matter of the Application of Homestake Mining Company for Groundwater Discharge Permit, DP-725, Renewal and Modification, January 12.

Baker, 2010b. Exhibit HMC 36C, "Environmental Monitoring Stations," attached to testimony of Kenneth L. Baker, in the Matter of the Application of Homestake Mining Company for Groundwater Discharge Permit, DP-725, Renewal and Modification, January 12.

Baker, 2010a. Exhibit HMC 36B, "Meteorological Data Wind Rose," attached to testimony of Kenneth L. Baker, in the Matter of the Application of Homestake Mining Company for Groundwater Discharge Permit, DP-725, Renewal and Modification, January 12.

deLemos, et al., 2008. J. deLemos, B. C. Bostick, A. Quicksall, J. Landis, C. C. George, N. Slagowski, T. Rock, D. Brugge, J. Lewis, J.L. Durant. Rapid Dissolution of Soluble Uranyl Phases in Arid, Mine-Impacted Catchments near Church Rock, NM. Environmental Science and Technology**,** 42:3951–3957.

DRSE Report, 2010. Draft Report February 2010: Focused Review of Specific Remediation Issues – An Addendum to the Remediation System Evaluation for the Homestake Mining Company (Grants) Superfund Site, New Mexico. Prepared for U.S. Environmental Protection Agency Region 6 by US Army Corps of Engineers, Environmental and Munitions Center of Expertise; February 15.

Eadie, et al., 1976. G. G. Eadie, R. F. Kaufmann, D. J. Markley, R. Williams. Report of ambient outdoor radon and indoor radon progeny concentrations during November 1975 at selected locations in the Grants Mineral Belt, New Mexico. Las Vegas, NV: U.S. Environmental Protection Agency, Office of Radiation Programs, ORP/LV-76-4, June.

EPA, 2010b. Radon Health Risks: Exposure to Radon Causes Lung Cancer in Non-smokers and Smokers Alike, www.epa.gov/radon/healthrisks.html; February 22.

EPA, 2010a. Aerial Radiological Survey of the Grants and Cebolleta Land Grant Areas in New Mexico. Prepared by Dynamic Corp. for U.S. Environmental Protection Agency Office of Emergency Management, National Decontamination Team (Cincinnati), January.

EPA, 2006. Second Five-Year Review Report for Homestake Mining Company Superfund Site, Cibola County, New Mexico. Dallas: U.S. Environmental Protection Agency, Region 6, September.

EPA, 2001. First Five-Year Review Report for Homestake Mining Company Superfund Site, Cibola County, New Mexico. Dallas: U.S. Environmental Protection Agency, Region 6, September.

EPA, 1989. U.S. Environmental Protection Agency. Record of Decision, Homestake Mining Company Radon Operable Unit, Cibola County, New Mexico, September 1989.

EQM, 2008. Environmental Quality Management, Inc. Draft Final Remediation System Evaluation Report for the Homestake Superfund Site, Milan, New Mexico. Prepared for U.S. Environmental Protection Agency Office of Research and Development (Cincinnati) and EPA Region 6 Superfund Program, December 19.

George and Breslin, 1978. A. C. George and A. J. Breslin. The Distribution of Ambient Radon and Radon Daughters in Residential Buildings in the New Jersey-New York Area. Natural Radiation Environment III, Volume 2, p. 1272. Springfield, VA: National Technical Information Service.

Gilliland et al., 2000. Gilliland FD, Hunt WC, Pardilla M, Key CR. Uranium mining and lung cancer among Navajo men in New Mexico and Arizona, 1969 to 1993. *Journal of Occupational and Environmental Medicine*; 42(3):278-83, March.

Homestake Mining Company of California (2000-2009). Semi-annual Environmental Monitoring Reports (SAEMR) for years 1999-2009; transmitted to U.S. Nuclear Regulatory Commission by HMC letters dated Feb. 24, 2000; Aug. 15, 2001; Feb. 21, 2002; Aug. 28, 2002; Feb. 26, 2003; Aug. 27, 2003; Feb. 24, 2004; Aug. 30, 2004; Feb. 24, 2005; Aug. 30, 2006; Feb. 20, 2007; Aug. 20, 2007; Feb. 20, 2008; Aug. 20, 2008; Feb. 25, 2009; Dec. 31, 2009.

Homestake Mining Company, 1989. Subdivisions Radon Study, Feasibility Study Report. Homestake Mining Company Grants Operation, June.

Millard and Baggett, 1984. Jere B. Millard, David T. Baggett. Radiological Assessment of the Populated Areas Southwest of the Homestake Mining Company Uranium Mill. Santa Fe: New Mexico Environmental Improvement Division, Radiation Protection Bureau, August.

NMED, 2010. Discharge Permit DP-725, amended April 12, 2010. Transmitted by certified letter from William C. Olsen, NMED Ground-water Quality Bureau, to Alan Cox, Homestake Mining Company, April 12.

NMED Secretary, 2010. State of New Mexico, Before the Secretary of Environment, No. GWQB 09-35(P), In the Matter of the Application of Homestake Mining Company for Groundwater Discharge Permit, DP-725, Renewal and Modification. Transcript of Proceedings, Volume I; testimonies of John Boomer, Arthur Gebeau, Candace Head-Dylla, Jonnie Head, Mark Head; January 12-13.

NMEI, 1974. An Environmental Baseline Study of the Mount Taylor Project Area of New Mexico. New Mexico Environmental Institute (Martha A. Whitson, Thomas O. Boswell); prepared for Gulf Minerals Resources Co., Project No. 3110-301, March.

NMMMD, 2009. Uranium mine database. Available from the New Mexico Mining and Minerals Division, Santa Fe.

Robinson, 2010. BVDA Exhibit 2, "Photographs, Maps and Diagrams Supplementing Direct Testimony of Wm. Paul Robinson on behalf of Bluewater Valley Downstream Alliance," in the Matter of the Application of Homestake Mining Company for Groundwater Discharge Permit, DP-725, Renewal and Modification, January 12.

Roscoe et al., 1995. Roscoe RJ, Deddens JA, Salvan A, Schnorr TM. Mortality among Navajo uranium miners. *American Journal of Public Health*; 85(4):535-40, April.

Samet and Mapel, 1998. Samet J, Mapel DW. Diseases of Uranium Miners and Other Underground Miners Exposed to Radon. Chapter 98 in *Environmental and Occupational Medicine*, WM Rom, ed. Philadelphia: Lippincott-Raven Publishers, 1307-1315.

Samet et al., 1984. Samet JM, Kutvirt DM, Waxweiler RJ, Key CR. Uranium mining and lung cancer in Navajo men. *New England Journal of Medicine*; 310(23):1481-4, June 7.

Shuey, et al., 2007. C. Shuey, J. deLemos, C. George. Uranium mining and community exposures on the Navajo Nation. Presentation to the annual meeting of the American Public Health Association (Washington, DC), November 7.

Simonds, et al., 2009. M.H. Simonds, M.J. Schierman, K.R. Baker. Radon Flux from Evaporation Ponds. Draft paper, 2009. (Available from Homestake Mining Co.)

TASC, 2009. "Summary and Review of Application for Modification and Renewal of NMED Discharge Permit DP-725, Effluent Disposal Facilities for the Ground Water Remediation System at the Homestake Mining Company, Grants Reclamation Project, Milan, N.M. Prepared by E^2 Inc. for U.S. Environmental Protection Agency Region 6 and Bluewater Valley Downstream Alliance, November 18.

Wagoner et al., 1975. Wagoner JK, Archer VE, Gillam JD. Mortality of American Indian Uranium Miners. Proceedings XI International Cancer Congress (Bucalossi P, Veronesi U, Cascinelli N, eds.), 3:102-107; *Excerpta Medica International Congress Services* No. 351.

WHO, 2009. World Health Organization, Geneva, Switzerland. WHO Handbook on Indoor Radon – a Public Health Perspective. Available at, http://www.who.int/mediacentre/factsheets/fs291/en/index.html.

Table 1.
Major Radon Monitoring Studies in the Grants Mineral Belt and Surrounding the Homestake Mining Company Grants Superfund Site, 1972-2009

Period	Organization(s)/ Reference(s)	Content	Monitors
1972-1973	New Mexico Environmental Institute (NMEI, 1974) for Gulf Minerals Resources	Radon baseline study with aircraft-based investigation of effects of temperature inversions on radon levels in San Mateo, New Mexico; part of environmental baseline study for proposed Mt. Taylor Uranium Mine	Taplex high-volume air samplers with discharge to scintillation cell (p. 68)
1975 (November)	EPA Office of Radiation Programs, Las Vegas, Nev. (Eadie et al., 1976)	Study of outdoor radon and indoor radon progeny levels at 10 sites in the Grants Mineral Belt	48-hr bag collection with discharge of air to scintillation cell
1978-1980	New Mexico Environmental Improvement Division (Buhl et al., 1985)	Study of outdoor radon levels at 27 sites, 21 sites in the Ambrosia Lake-Milan-Bluewater region and six sites in places where uranium mining and milling had not previously occurred	Outdoor radon: 48-hr bag collection with discharge of air to scintillation cell; Indoor radon progeny: Radon Progeny Integrating Sampling Units provided by EPA
1983-1984	NMEID (Millard and Baggett, 1984)	Radiological assessment of residential areas southwest of the HMC site with monitors located in Murray and Broadview Acres and villages of San Mateo and Bluewater	PERMs (Passive Environmental Radon Monitors) provided by EPA
1987-1988	Homestake Mining Co. (Carter 1988, HMC 1989, USEPA, 1989)	Subdivisions Radon Study conducted in 59 homes and at 28 outdoor stations	Initial screening: three-day charcoal canisters; long-term monitoring with Terradex Track-Etch monitors
1999-2009	Homestake Mining Co. (HMC, 2000-2009)	Radon data from HMC's seven perimeter air monitoring sites and one background monitor station, extracted from HMC's SAEMRs	Terradex Track-Etch monitors

Table 2.
Summary of Average Annual Radon Levels at Background and Non-Background Locations in Ambrosia Lake-Milan Uranium Mining District, 1972-2009
(all concentrations in picocuries per liter-air)

Year / Period	Study Area	Background: # monitors (# samples)	Background: Average Rn (range)	Non-background: # monitors (# samples)	Non-background: Average Rn[a] (range)	References
1972-73	San Mateo, NM	3 (135)	**0.19** (0.08-.59)	None	None	GMR: **NMEI, 1974**
Nov. 1975	Ambrosia Lake-Milan	5 (5)	**0.71±0.47** (0.11-1.2)	5 (5)	2.58±0.73 (1.9-3.6)	USEPA: **Eadie et al., 1976**
1978-79	Ambrosia Lake-Milan	9 (122)	**0.57±0.69** (0.10-1.12)	AL: 6 (110)	***3.20±2.53*** (2.01—4.23)	NMEID: **Buhl et al., 1985 (17)**
				HMC: 3 (53)	***1.83±1.24*** (1.55—2.01)	
				AC: 2 (38)	***1.06±0.75*** (0.76-1.37)	
1979-80	Ambrosia Lake-Milan	10 (187)	**0.50±0.58** (0.14-0.81)	AL: 6 (136)	***4.66±2.89*** (3.23-6.40)	NMEID: **Buhl et al., 1985 (18, 28)**
1978-80	Bluewater Lake, Cebolleta, Crownpoint, Gulf Mill Site, Nose Rock, San Mateo	6 (115)	**0.19±0.02** (0.13-0.25)	HMC: 3 (67)	***1.51±1.02*** (1.51—1.89)	
				AC: 2 (42)	***0.87±0.64*** (0.78-0.95)	
1983-84	San Mateo and Bluewater Village	2 (52)	**0.35±0.02** (no range)	MA and BA: 5 (130)	**1.62** (no sd or range given)	NMEID: **Millard & Baggett, 1984**
1987-88 (15 mo.)	Residential area south and southwest of HMC site	28 (112)	**1.9±0.4**[b] (range of corrected Rn values, 1.2-2.7) (range of maximum Rn values, 2.8-8.2)			HMC: **EPA, 1989**
1999-2009*	Perimeter of HMC-licensed area	HMC #16 (21)	**1.16±0.36** (0.8-2.5)	HMC #4 (20)	**1.80±0.33** (1.1-2.4)	**HMC, 2000-2009**
				HMC #5 (20)	**1.63±0.32** (1.2-2.2)	
				HMC #1,2,3,6,7[d] (100)	**1.38±.0.35** (0.8-2.8)	
2010	United States	Not given	**0.4 (average outdoor Rn)**	n/a	n/a	**EPA 2010**

Abbreviations: AC = Anaconda Co.; AL = Ambrosia Lake Mill (Kerr-McGee Corp./Quivira Mining Co.); BA = Broadview Acres; GMR = Gulf Mineral Resources; HMC = Homestake Mining Co.; MA = Murray Acres; NMEID = New Mexico Environmental Improvement Division; sd = standard deviation; EPA = U.S. Environmental Protection Agency

Table 3a.
Ambient Radon-222 Concentrations at HMC Perimeter Air Monitoring Stations, 1999-2009
(all concentrations in picocuries per liter air)

Year	Period	HMC #1	HMC #2	HMC #3	HMC #4	HMC #5	HMC #6	HMC #7	HMC #16	Reference
1999	2nd half	2.0	1.6	1.1	1.7	1.6	1.7	1.2	1.1	HMC-SAEMR, 2/24/00
2000	1st half	1.4	1.5	1.2	1.9	1.2	1.1	1.0	0.9	HMC-SAEMR, 8/8/00
2000	2nd half	2.2	1.6	1.2	2.0	1.8	1.1	1.1	1.1	EPA, 2001 (Table 4)
2001	1st half	1.5	2.2	1.2	1.8	2.0	1.4	1.7	1.1	HMC-SAEMR, 8/15/2001
2001	2nd half	1.1	1.3	0.7	1.4	1.4	1.1	1.1	1.1	HMC-SAEMR, 2/21/02
2002	1st half	1.3	1.6	1.1	1.6	1.3	1.5	1.1	0.9	HMC-SAEMR, 8/28/02
2002	2nd half	1.5	1.3	1.1	1.5	1.3	1.2	1.1	0.9	HMC-SAEMR, 2/26/03
2003	1st half	1.6	2.3	1.2	1.2	1.5	0.9	1.2	0.9	HMC-SAEMR, 8/27/03
2003	2nd half	1.7	1.5	1.1	2.3	1.5	1.6	1.4	1.0	HMC-SAEMR, 2/24/04
2004	1st half	1.1	0.9	0.6	1.1	1.2	1.7	0.8	1.5	HMC-SAEMR, 8/30/04
2004	2nd half	1.6	1.4	1.2	1.8	1.7	1.6	1.2	1.0	HMC-SAEMR, 2/24/05
2005	1st half	1.2	1.8	0.9	1.8	1.4	1.4	1.3	1.2	EPA, 2006 (Table 4)
2005	2nd half	1.5	1.5	1.2	2.0	1.7	1.6	1.3	1.1	HMC-SAEMR, 2/24/06
2006	1st half	1.2	1.7	1.1	2.2	2.1	1.1	1.2	1.0	HMC-SAEMR, 8/30/06
2006	2nd half	1.7	2.0	1.0	2.1	1.8	1.4	1.3	1.0	HMC-SAEMR, 2/20/07
2007	1st half	1.5	1.0	0.7	1.8	1.3	1.3	0.9	0.8	HMC-SAEMR, 8/20/07
2007	2nd half	1.9	1.7	1.6	2.4	1.8	1.7	1.6	1.6	HMC-SAEMR, 2/25/08
2008	1st half	1.4	1.6	1.4	1.8	2.2	1.6	1.3	1.3	HMC-SAEMR, 8/20/08
2008	2nd half	1.3	1.6	1.2	1.7	2.2	2.8	1.2	1.2	HMC-SAEMR, 2/25/09
2009	1st half								1.2	HMC-SAEMR, 12/31/09
2009	2nd half	1.6	1.8	1.4	1.8	1.5	1.4	1.2	2.5	HMC-SAEMR, 12/31/09

Table 3b.
Results of t-Test* of Two Samples Assuming Unequal Variance
for Radon Levels in HMC Perimeter Air Monitors
(all concentrations in pCi/l-air)

Station	N	Mean	Std. Dev.	Median	Max	Min	*p*-value**
HMC #1	20	1.52	0.29	1.50	2.2	1.1	*<0.002*
HMC #2	20	1.60	0.34	1.60	2.3	0.9	*<0.0004*
HMC #3	20	1.11	0.24	1.15	1.6	0.6	0.59
HMC #4	20	1.80	0.33	1.80	2.4	1.1	*<0.0000001*
HMC #5	20	1.63	0.32	1.55	2.2	1.2	*<0.0002*
HMC #6	20	1.46	0.40	1.40	2.8	0.9	*<0.02*
HMC #7	20	1.21	0.21	1.20	1.7	0.8	0.605
HMC #16	21	1.16	0.36	1.10	2.5	0.8	n/a

*Normal distribution of Rn values assumed, based on examination of differences in calculated mean and median values.

***p* is the probability that radon levels at HMC air monitors are significantly different than radon levels in HMC #16 at $\alpha \leq 0.05$. *p*-values in *italic* signify a significant difference in average radon levels.

Table 4.
Radon-Radon Daughter Equilibrium Estimates in Regional Studies

Study (Reference)	Technical Basis	EF Estimate(s)
1975 EPA Study (Eadie et al., 1976, p. 9)	"Percent Equilibrium" was calculated for each of the 10 monitoring stations in the study	Range of EF: 40% - 129%; average of all EFs: 73.7% (0.737)
1978-1980 NMEID Study (Buhl et al., 1985, p. 42)	Outdoor radon was correlated with indoor radon progeny concentration	EF = 50% (0.50)
1983-84 NMEID Radiological Assessment (Millard and Baggett, 1984, p. 2)	Calculated EF from average wind speed from HMC tailings to residences, distance from tailings to homes, travel time from source to target for in-growth of radon daughters	EF = 28% (0.28) Also cited study by George and Breslin (1978) in which an EF of 83% was calculated from outdoor radon and radon daughter levels.

Table 5.
Comparison of HMC-Calculated Total Effective Dose Equivalent (TEDE) at Nearest-Residence Air Monitoring Station (HMC #4) with Doses Calculated Using Different Background Radon Values and Different Assumptions for Occupancy Factor (OF) and Radon-Radon Daughter Equilibrium Factor (EF)
(doses in *italics* exceed NRC's 10 CFR 20.1301(a)(1) limit of 100-mrem/y to member of the public)

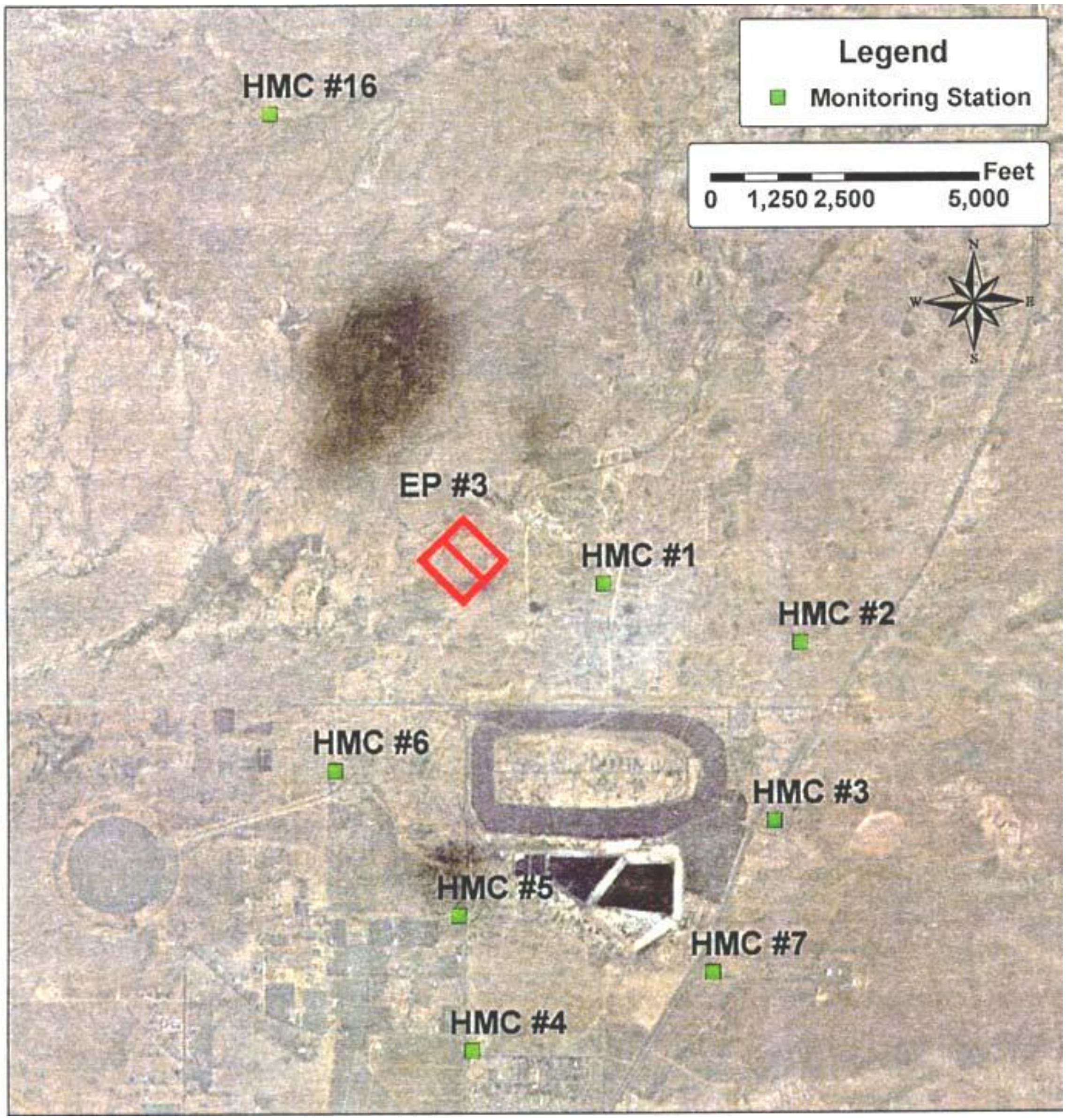
Nearest Residence Radon HMC #4 (2009)	Back-ground Radon	Background Station(s) (Year)	HMC Base Case: OF = 0.75 EF = 0.2	OF = 1.0 EF = 0.2	OF = 0.75 EF = 0.5	OF = 1.0 EF = 0.5
pCi/l	pCi/l		mrem/y			
1.8	1.3	HMC #16 (2009)	46.3	58.8	*102.6*	*133.8*
1.8	1.12	NMEID #201 (1979) (comparable with ave. Rn level of 1.16 in HMC #16)	59.8	76.8	*136.3*	*178.8*
1.8	0.81	NMEID #201 (1980)	83.1	*107.8*	*194.4*	*256.3*
1.8	0.53	NMEID #211, #212, #219, #220, #316, #415 (1983)	*104.1*	*135.8*	*246.9*	*326.3*
1.8	0.19	San Mateo (1972-73); Bluewater Lake, Crownpoint, Gulf Mill Site, San Mateo (1978-80)	*129.6*	*169.8*	*310.7*	*411.3*

Table 6.
Lifetime Risk of Lung Cancer from Indoor Radon Exposure – Non-smoking and Smoking
(Source: EPA, 2010)

Radon Level (pCi/l*)	Lifetime Cancer Risk Among Non-smokers	Lifetime Cancer Risk Among Smokers	Remediation Recommendations
20	36 in 1,000 (3.6 x 10^{-2})	260 in 1,000 (2.6 x 10^{-1})	Ventilate your home
10	18 in 1,000 (1.8 x 10^{-2})	150 in 1,000 (1.5 x 10^{-1})	Ventilate your home
8	15 in 1,000 (1.5 x 10^{-2})	120 in 1,000 (1.2 x 10^{-1})	Ventilate your home
4**	7 in 1,000 (7 x 10^{-3})	62 in 1,000 (6.2 x 10^{-2})	Ventilate your home
2	4 in 1,000 (4 x 10^{-3})	32 in 1,000 (3.2 x 10^{-2})	Consider ventilating or fixing your home
1.3***	2 in 1,000 (2 x 10^{-3})	20 in 1,000 (2 x 10^{-2})	Consider fixing your home, but may be difficult
0.4	No risk estimated	No risk estimated	None recommended

*pCi/l = picocuries per liter air
**EPA “action level” for indoor radon
***Average indoor radon level in United States., according to EPA

Figure 1
Air Monitoring Stations at the Homestake Mining Company Superfund Site
(Source: Baker, 2010b)



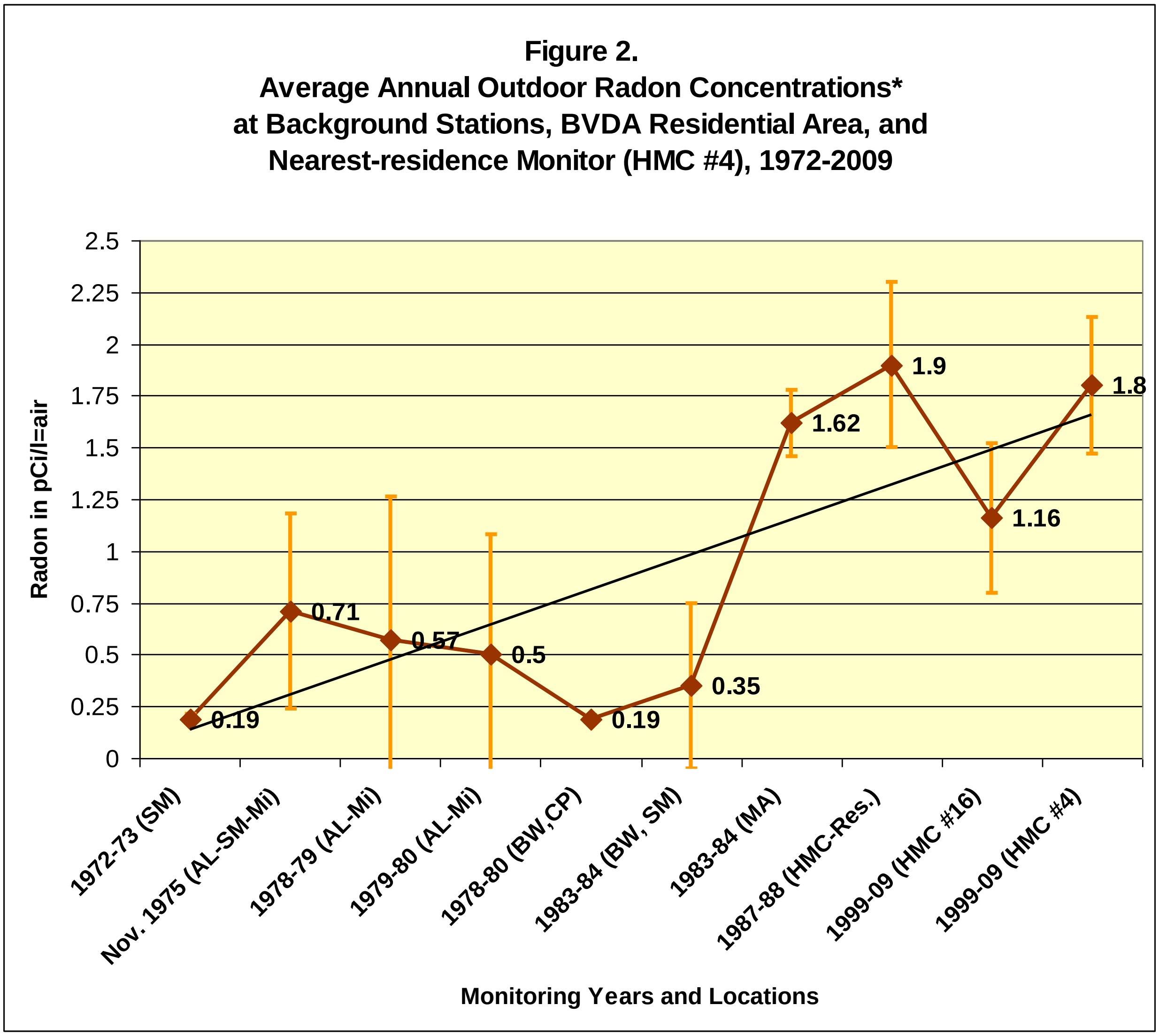


Figure 2.
Average Annual Outdoor Radon Concentrations*
at Background Stations, BVDA Residential Area, and
Nearest-residence Monitor (HMC #4), 1972-2009
Radon in pCi/l=air
2.5
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
0.19
0.71
0.57
0.5
0.19
0.35
1.62
1.9
1.16
1.8
1972-73 (SM)
Nov. 1975 (AL-SM-Mi)
1978-79 (AL-Mi)
1979-80 (AL-Mi)
1978-80 (BW,CP)
1983-84 (BW, SM)
1983-84 (MA)
1987-88 (HMC-Res.)
1999-09 (HMC #16)
1999-09 (HMC #4)
Monitoring Years and Locations

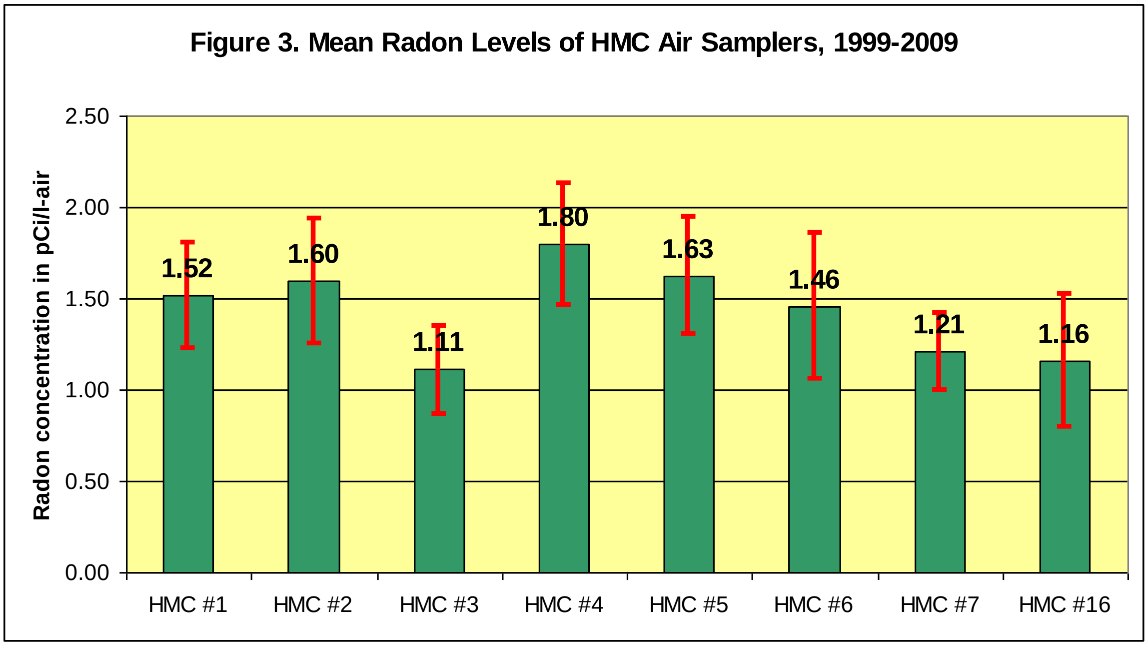


Figure 3. Mean Radon Levels of HMC Air Samplers, 1999-2009
Radon concentration in pCi/l-air
2.50
2.00
1.50
1.00
0.50
0.00
1.52
1.60
1.11
1.80
1.63
1.46
1.21
1.16
HMC #1
HMC #2
HMC #3
HMC #4
HMC #5
HMC #6
HMC #7
HMC #16

Figure 4.
Soil Assessment Sample Results, Uranium and Ra-226
(Source: Baker, 2010c)

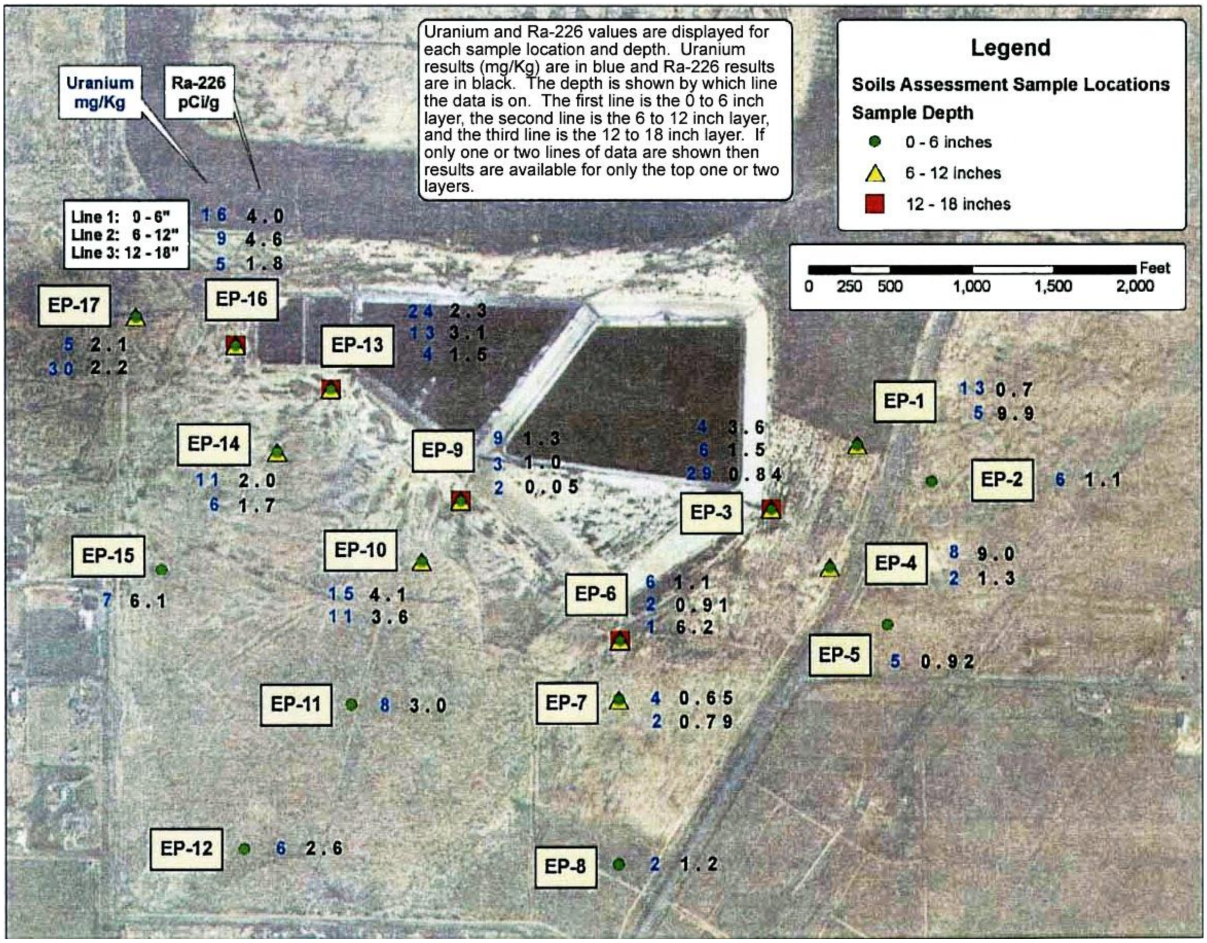
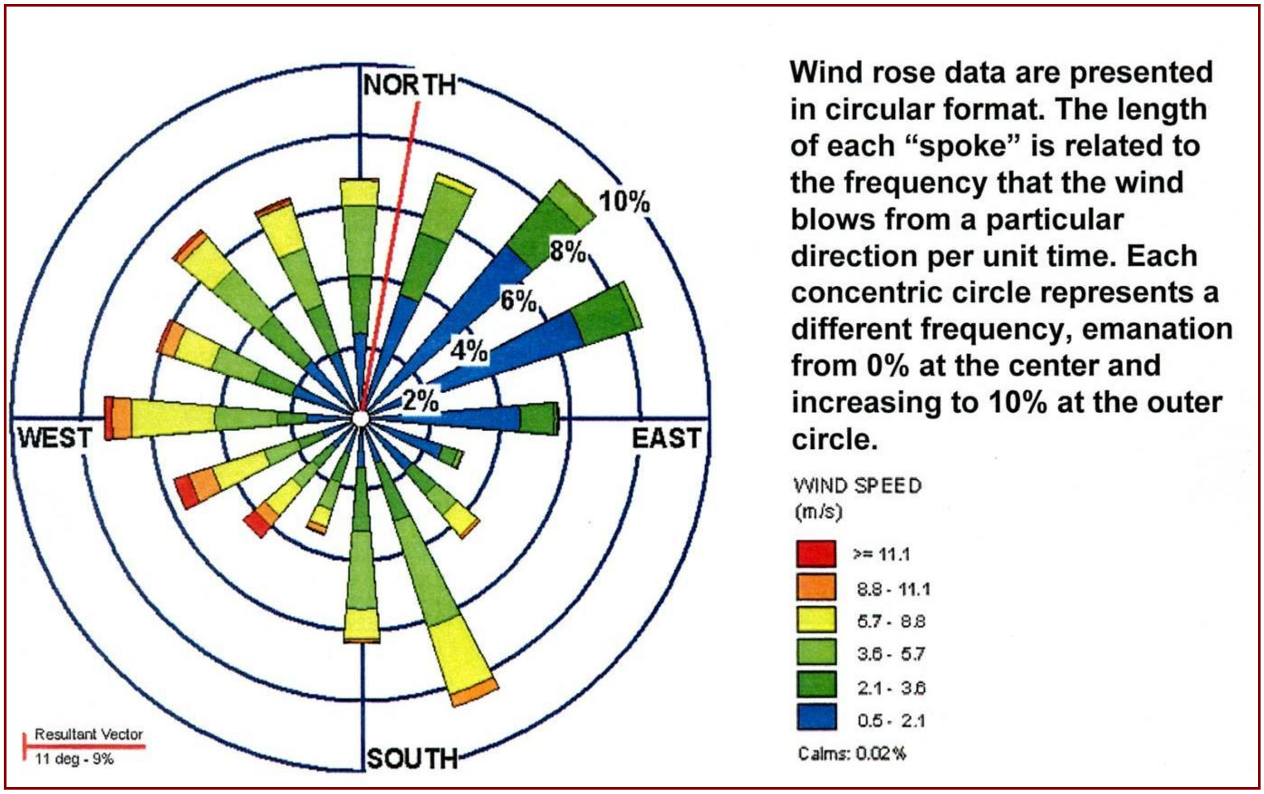
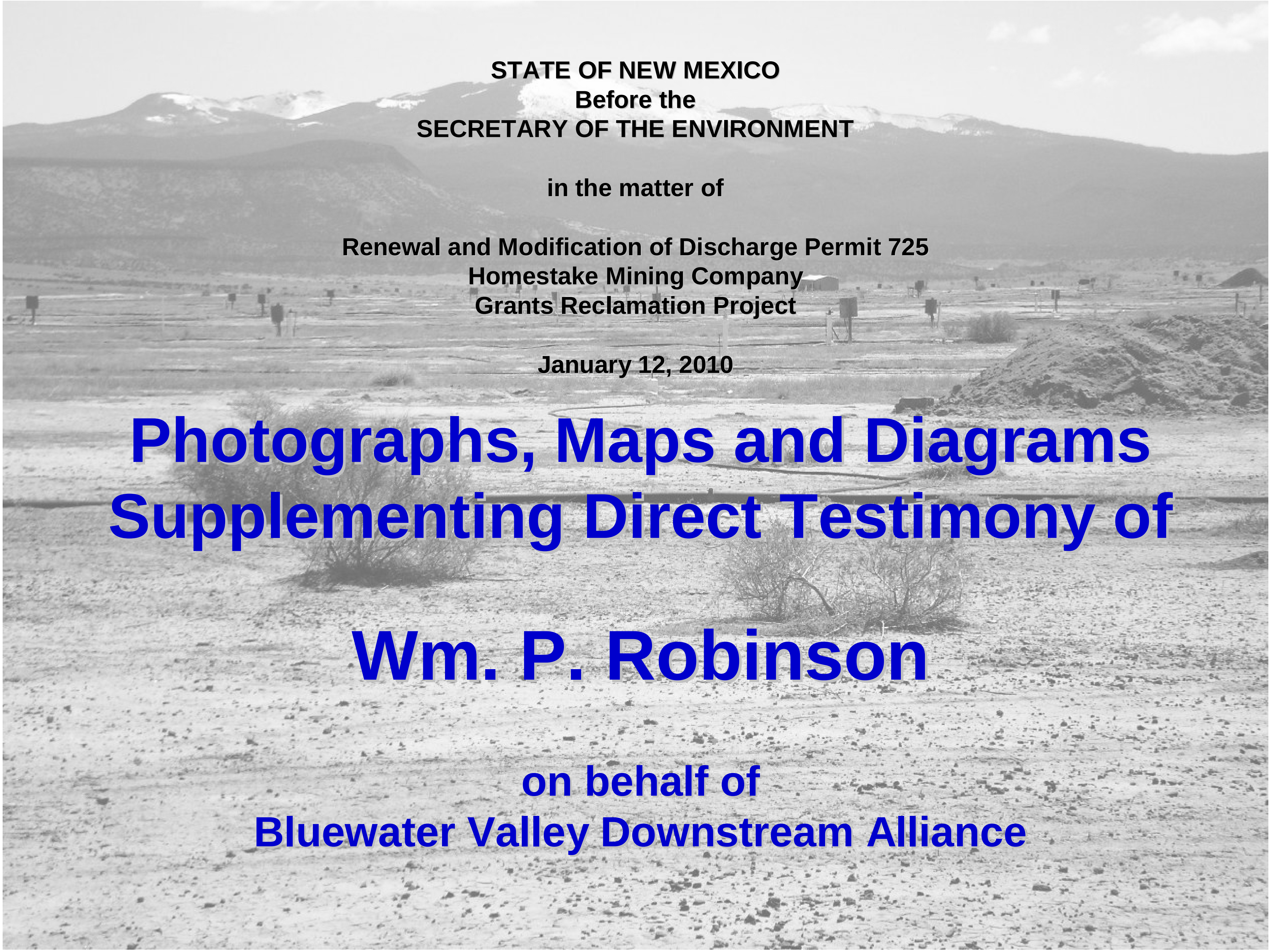


Figure 5.
Meteorological Data Wind Rose
For Homestake Mining Company Superfund Site
(Source: Baker, 2010a)



Appendix A

"Photographs, Maps and Diagrams Supplementing Direct Testimony of Wm. Paul Robinson on behalf of Bluewater Valley Downstream Alliance," in the Matter of the Application of Homestake Mining Company for Groundwater Discharge Permit, DP-725, Renewal and Modification
January 12, 2010



STATE OF NEW MEXICO
Before the
SECRETARY OF THE ENVIRONMENT

in the matter of

Renewal and Modification of Discharge Permit 725
Homestake Mining Company
Grants Reclamation Project

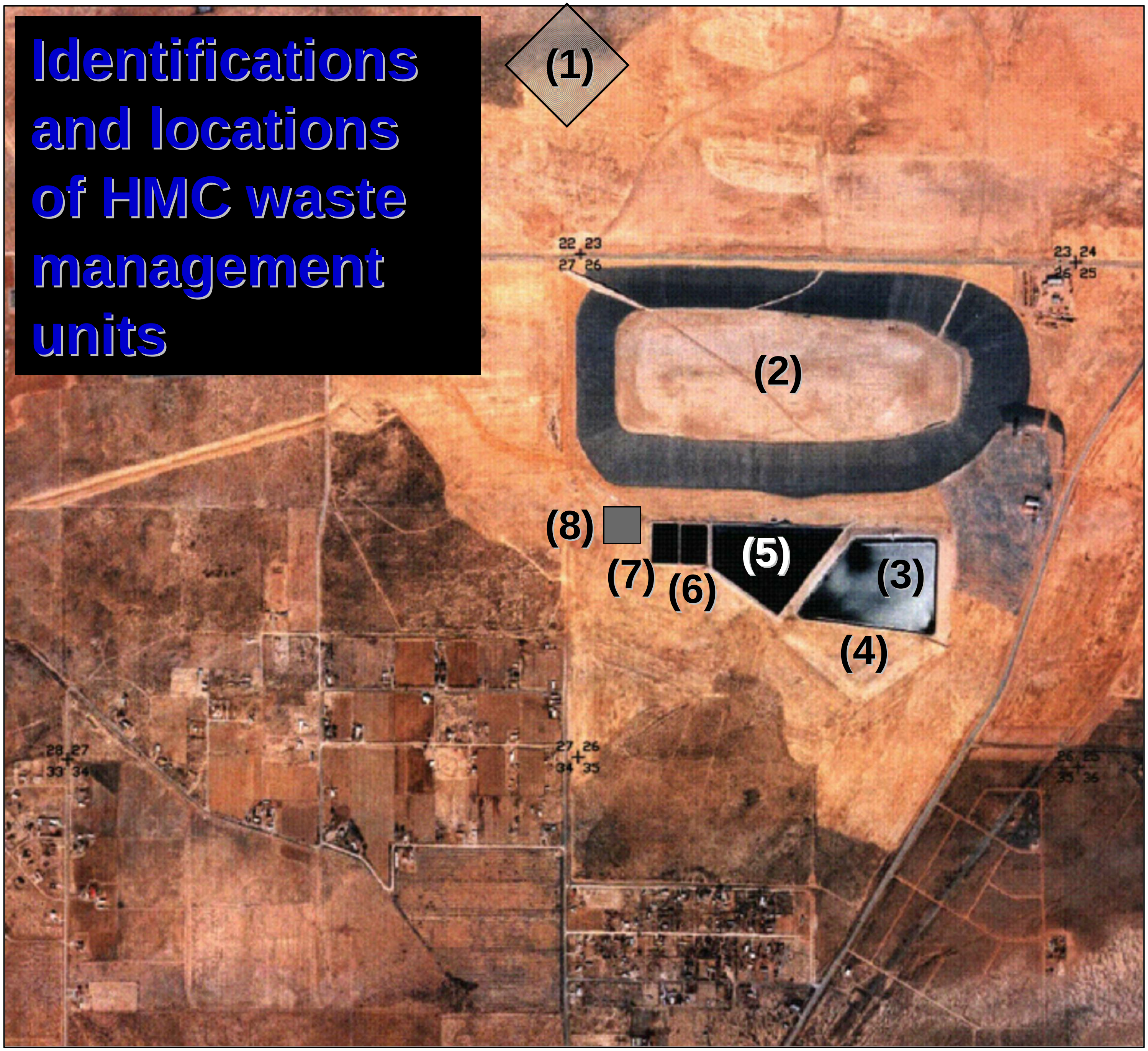
January 12, 2010

Photographs, Maps and Diagrams Supplementing Direct Testimony of

Wm. P. Robinson

on behalf of
Bluewater Valley Downstream Alliance

Identifications and locations of HMC waste management units



(1) Proposed Evaporation Pond 3 (size and location approximate)

(2) Large Tailings Pile

(3) Evaporation Pond 1

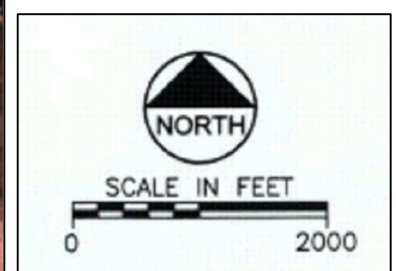
(4) Small Tailings Pile

(5) Evaporation Pond 2

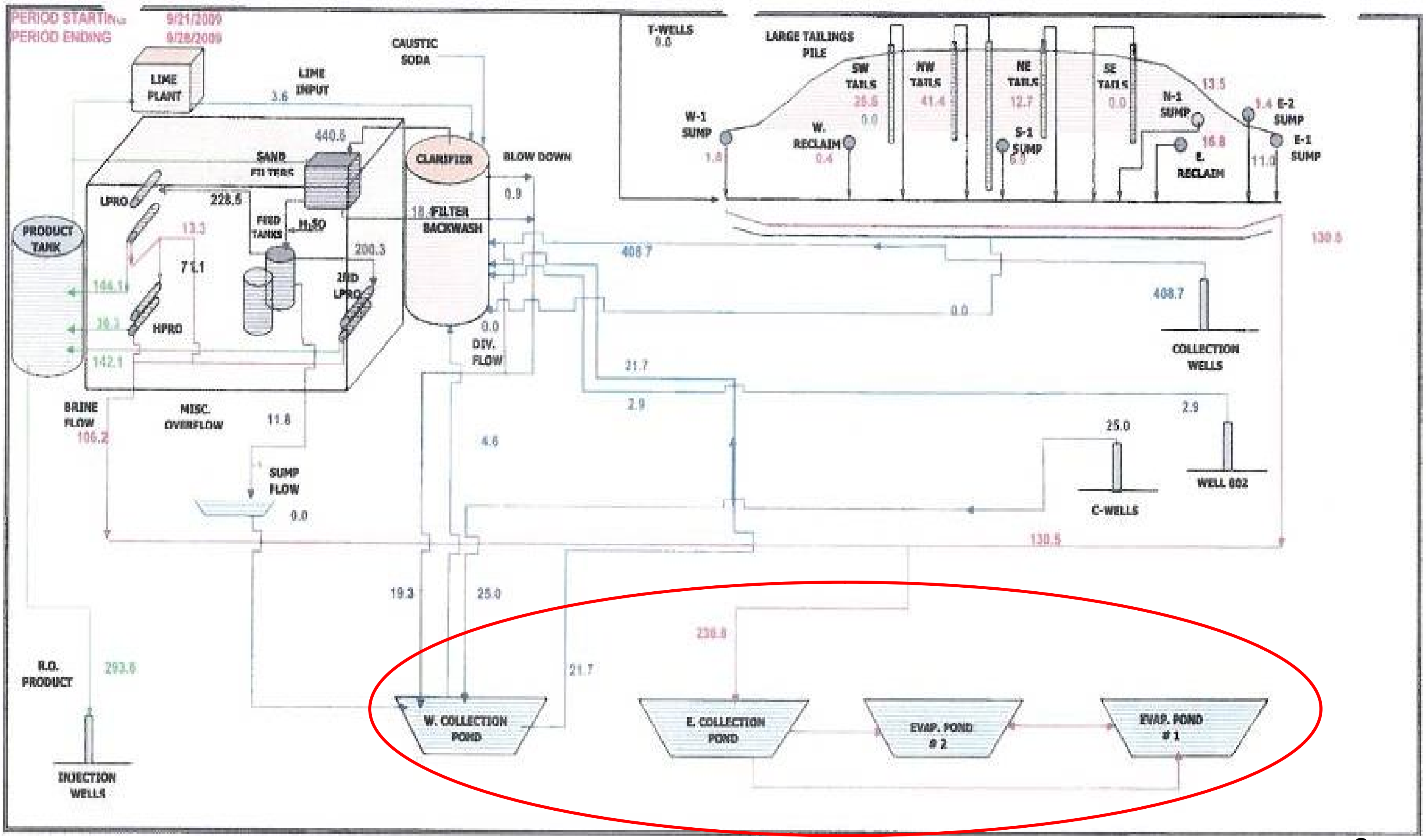
(6) East Collection Pond

(7) West Collection Pond

(8) Reverse Osmosis Plant



Schematic Diagram Summarizing Flows of Liquids and Reverse Osmosis Plant Residues to HMC Waste Management Units for week ending Sept. 28, 2009



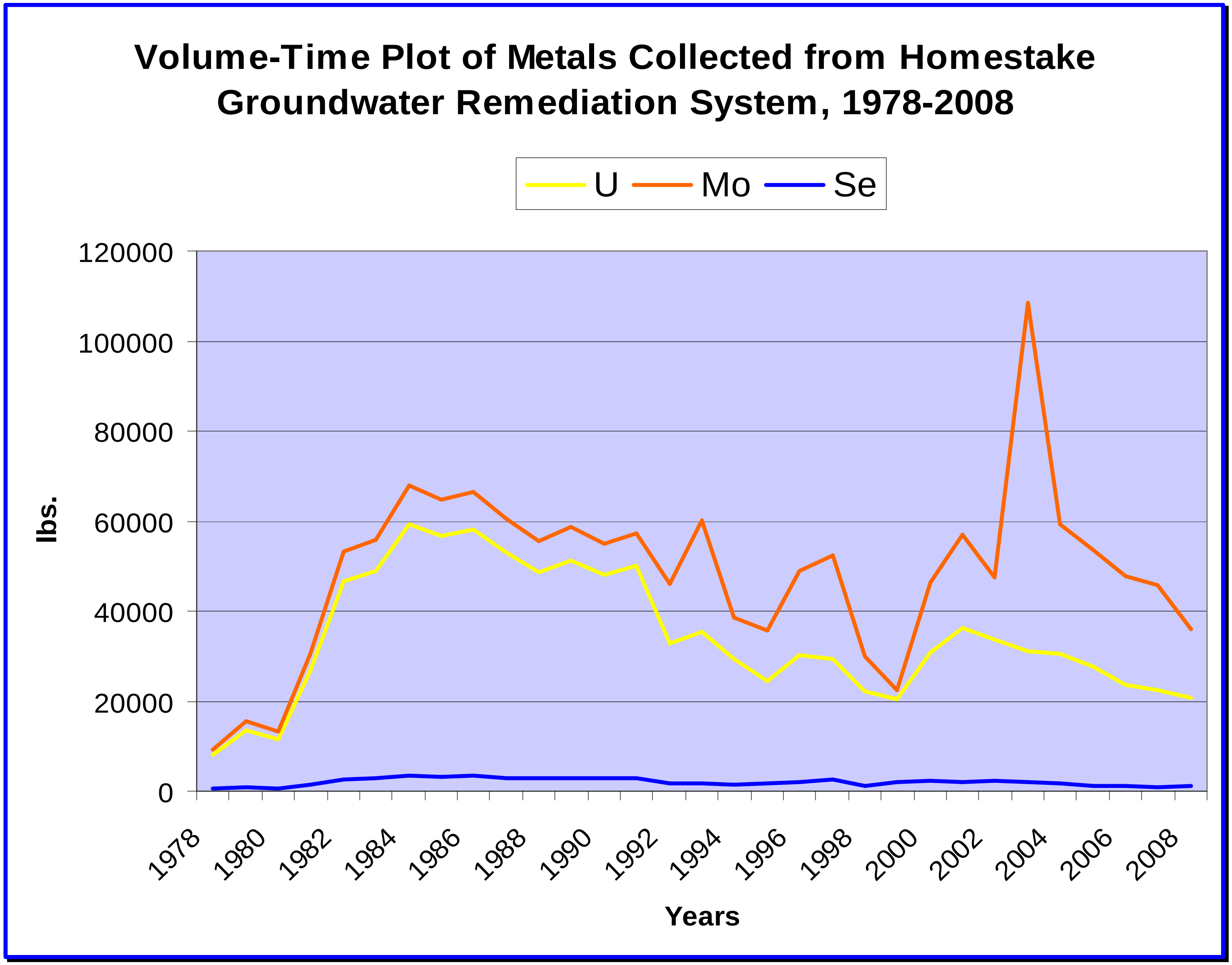
Source: "Example Weekly Report.pdf" provided by Homestake to RSE QuickPlace website

Homestake Mining Co.
DP-725

Effluent Management Facilities

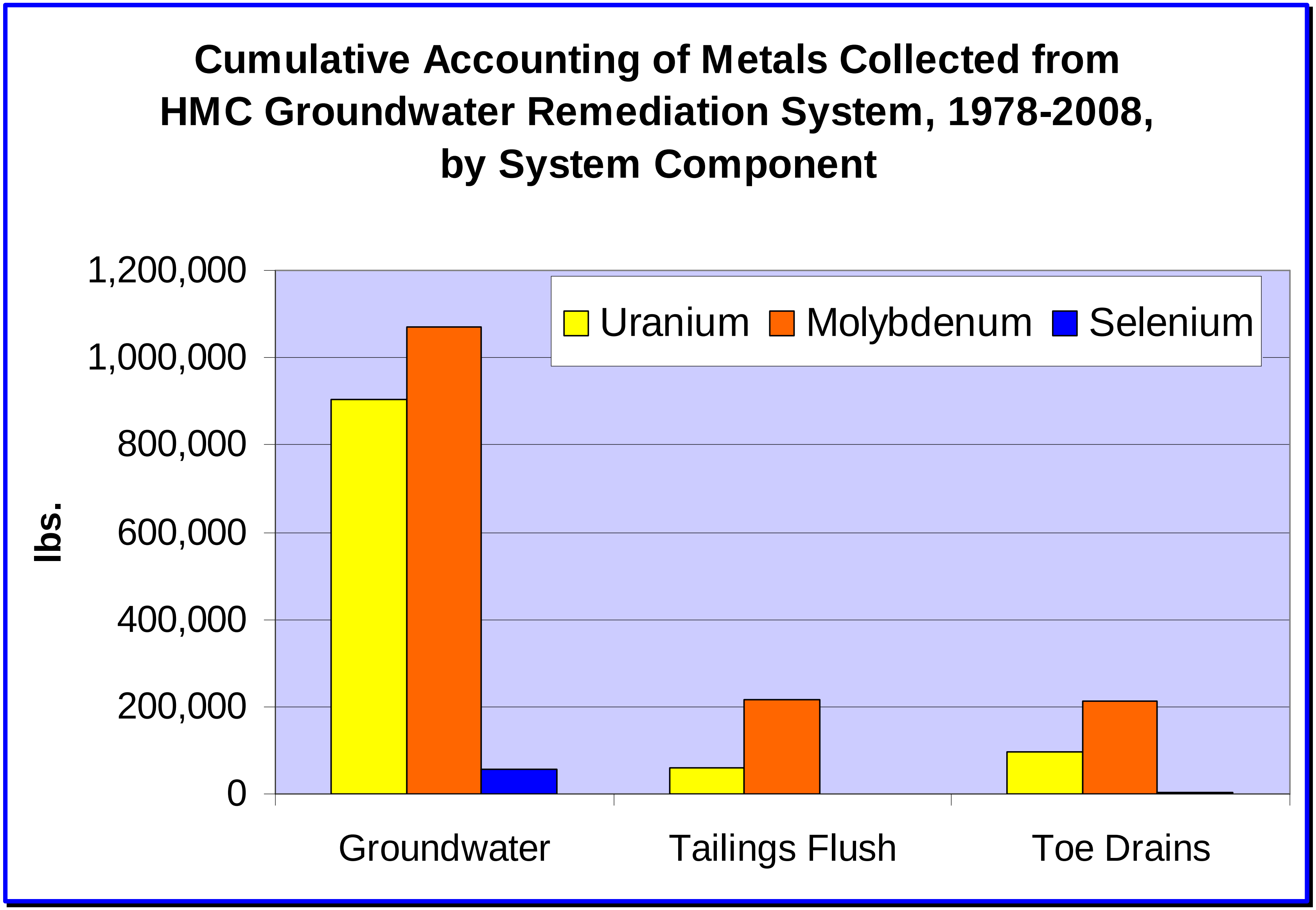
Waste Characterization and Monitoring Issues

Chart 1



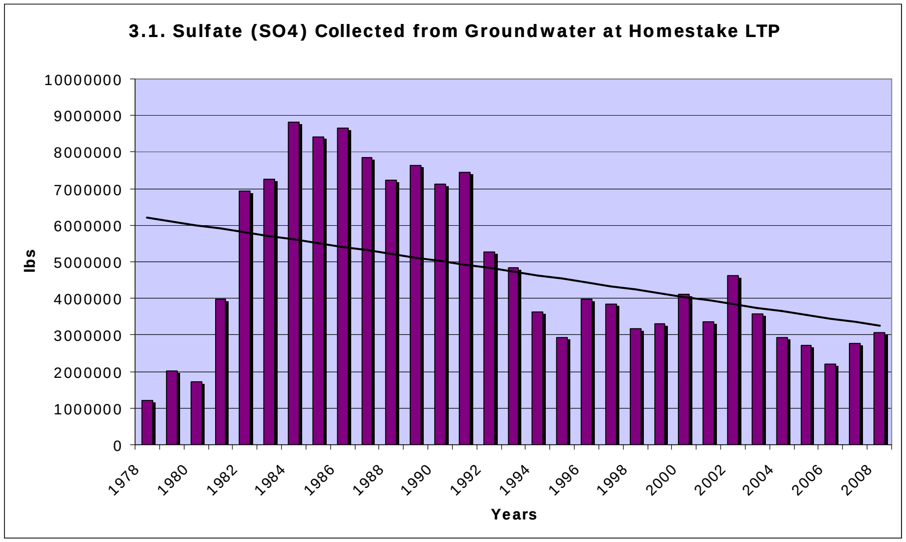
Volume-Time Plot of Metals Collected from Homestake Groundwater Remediation System, 1978-2008
U
Mo
Se
120000
100000
80000
60000
40000
20000
0
lbs.
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Years

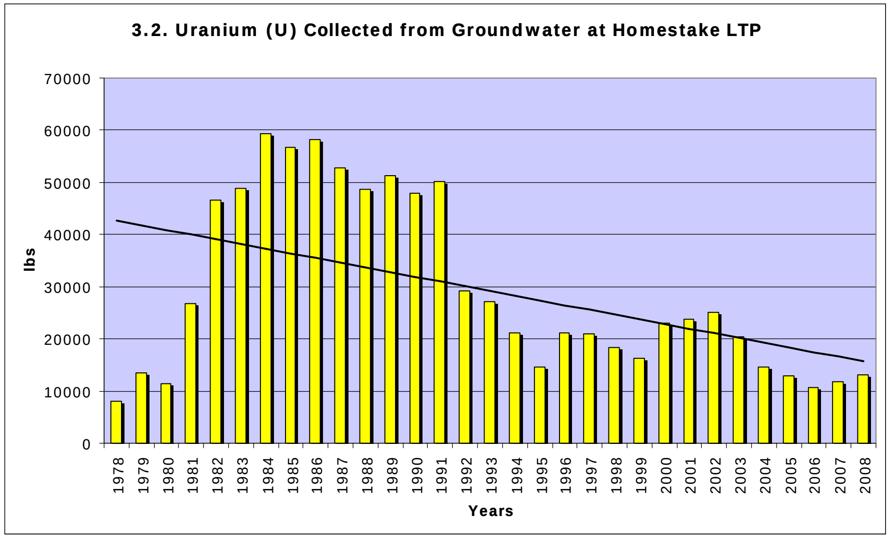
Chart 2

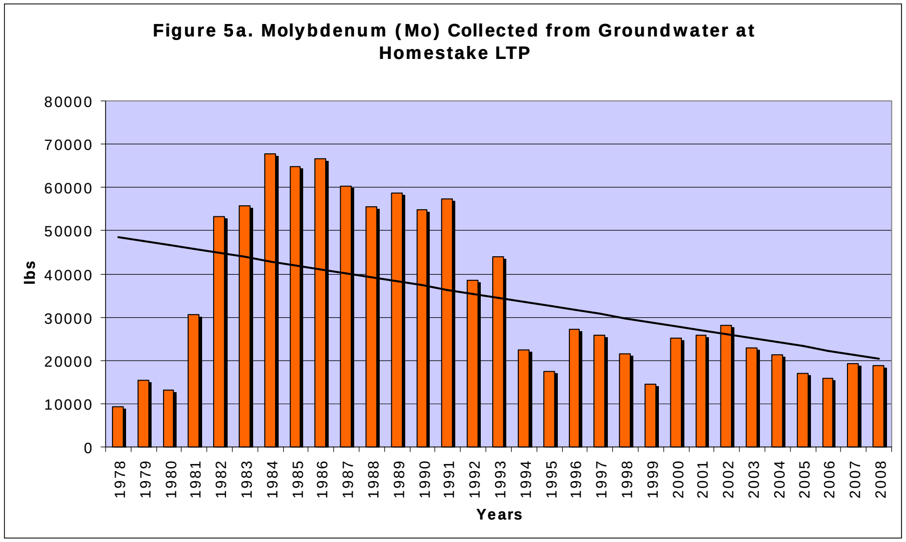


Cumulative Accounting of Metals Collected from
HMC Groundwater Remediation System, 1978-2008,
by System Component
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
lbs.
Uranium
Molybdenum
Selenium
Groundwater
Tailings Flush
Toe Drains

Chart 3:
Constituents Collected from Groundwater







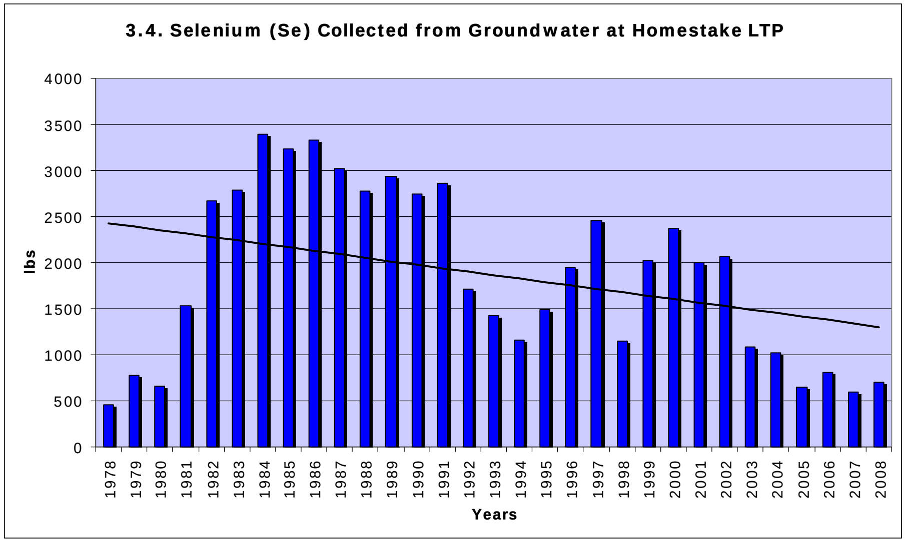
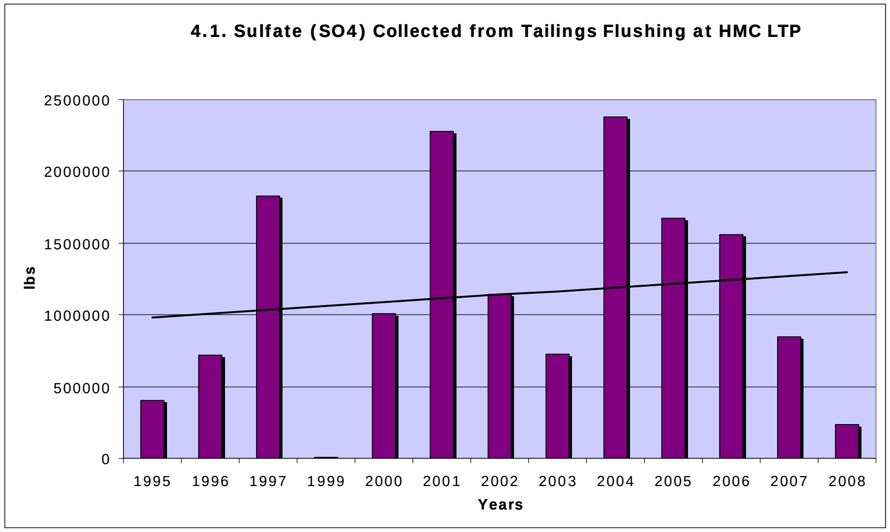
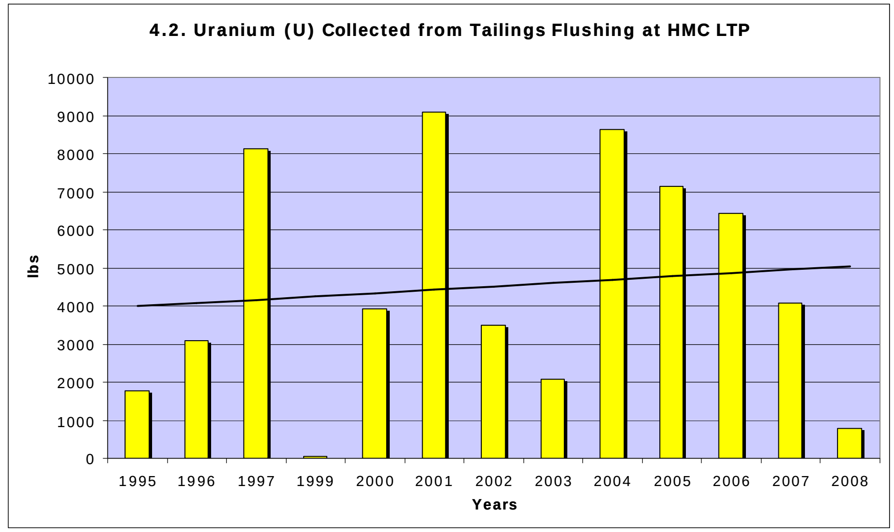
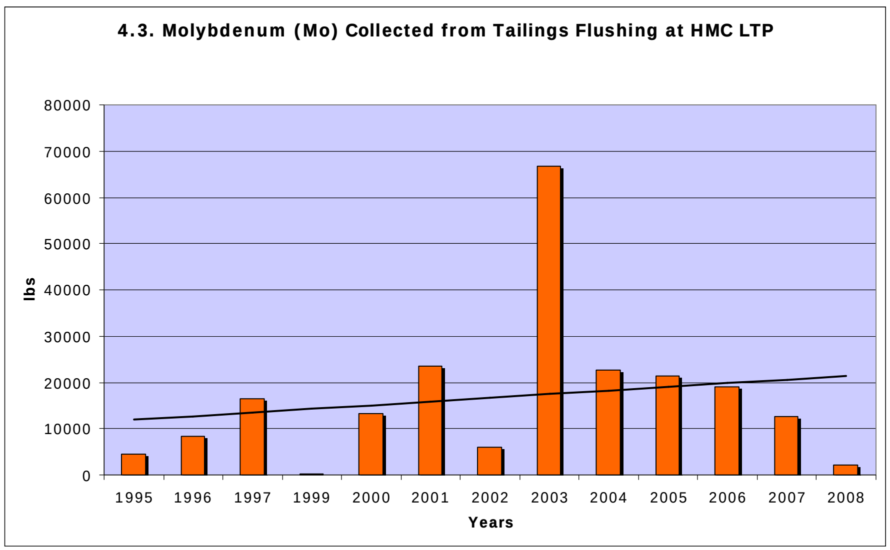


Chart 4:
Constituents Collected from Tailings Flushing







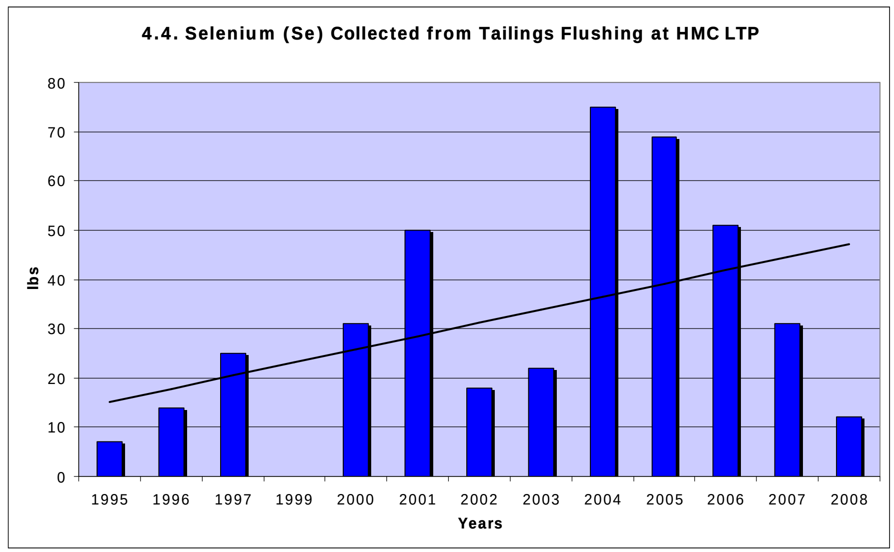
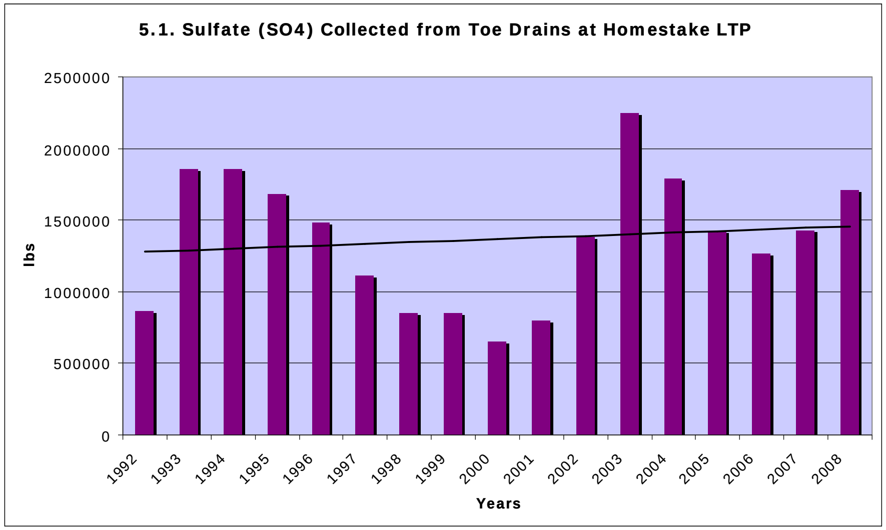
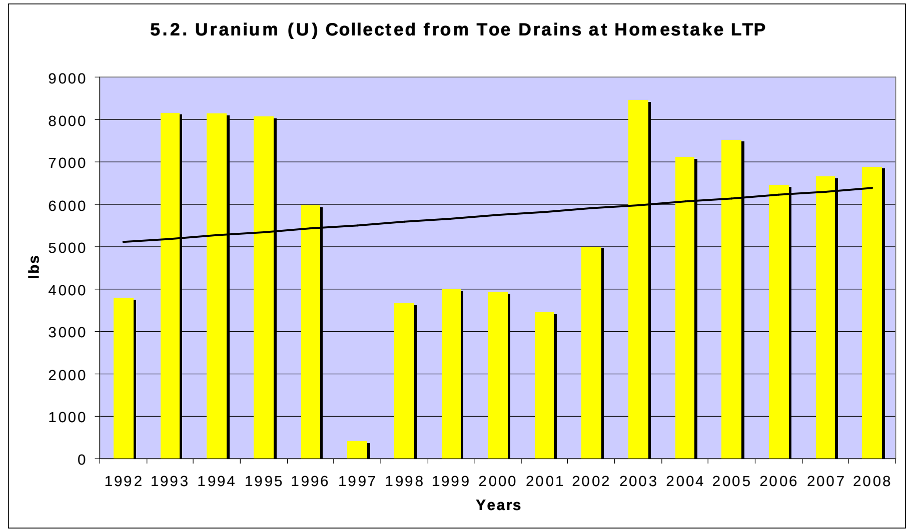
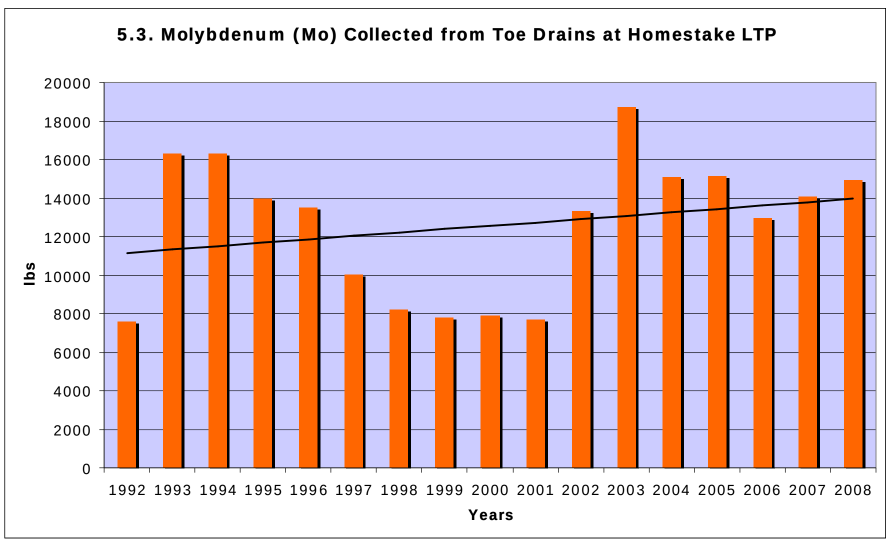
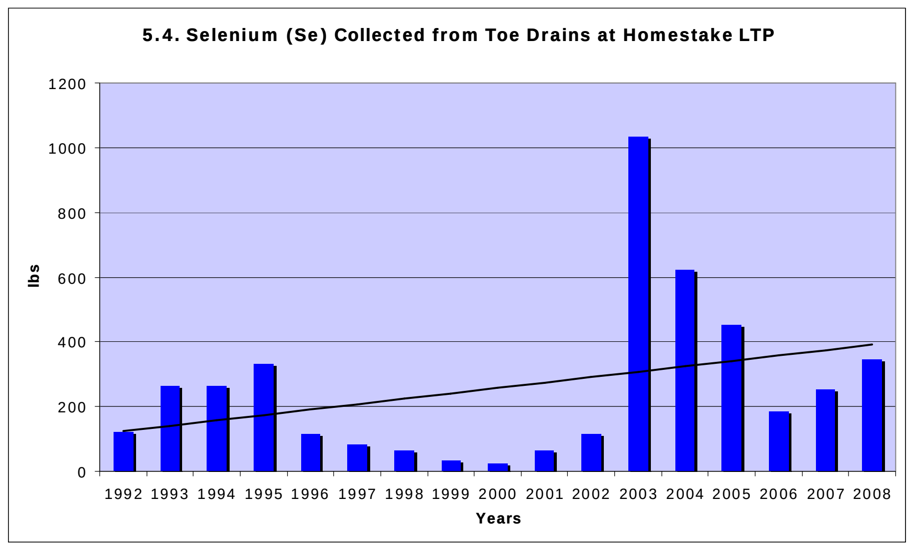


Chart 5:
Constituents Collected from Toe Drains









NMEID Radon Monitoring Stations, 1979-1981

(from Buhl, et al., 1985, p. 13)

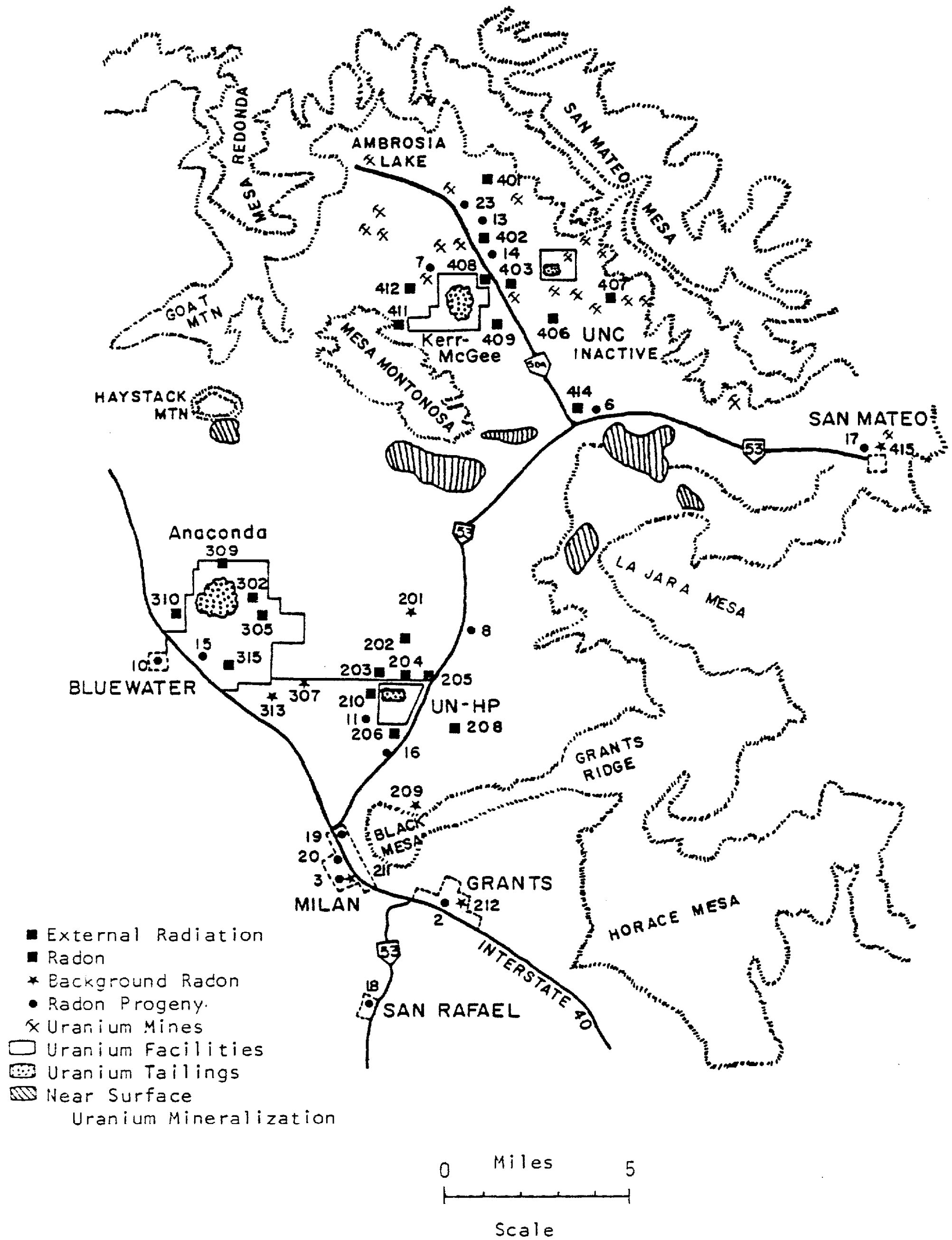


Figure 3.1 Sampling Locations and Station Numbers

NMEID Ambient Rn-222 Levels, 1979-1981

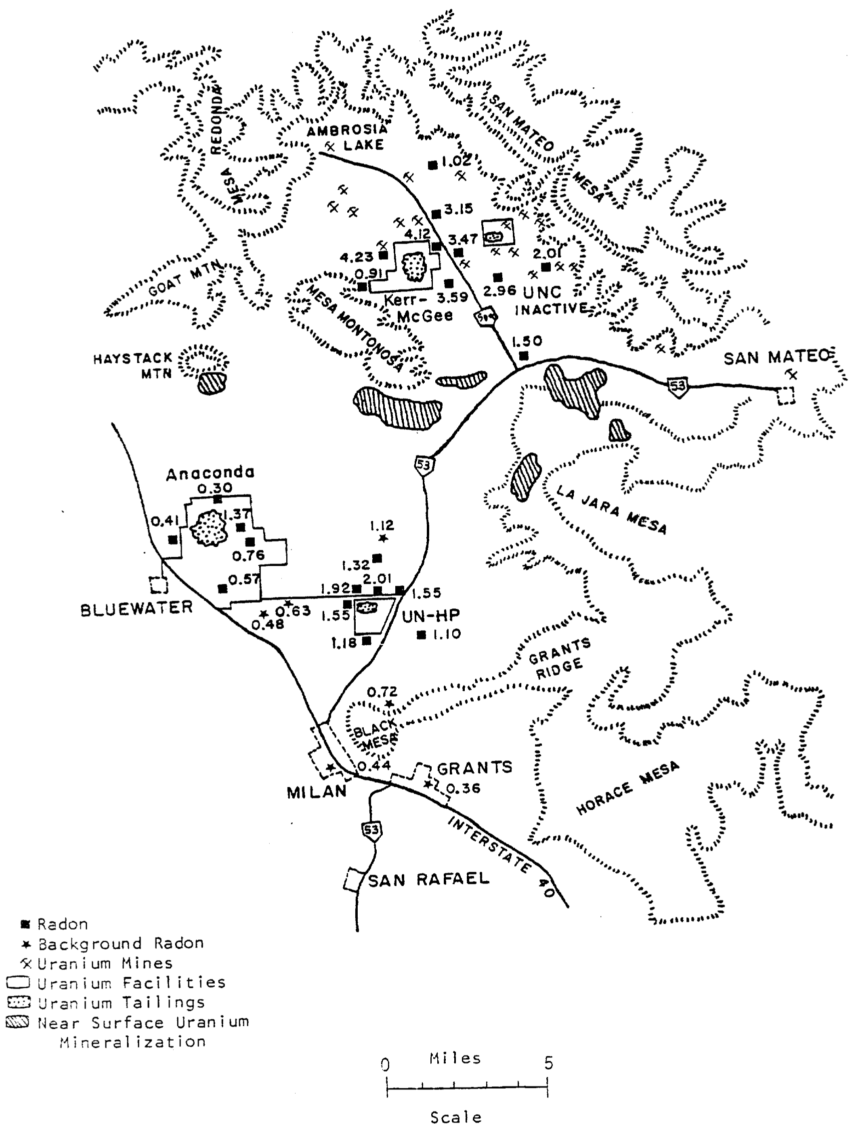


Figure 3.2 First Year Radon Averages By Station

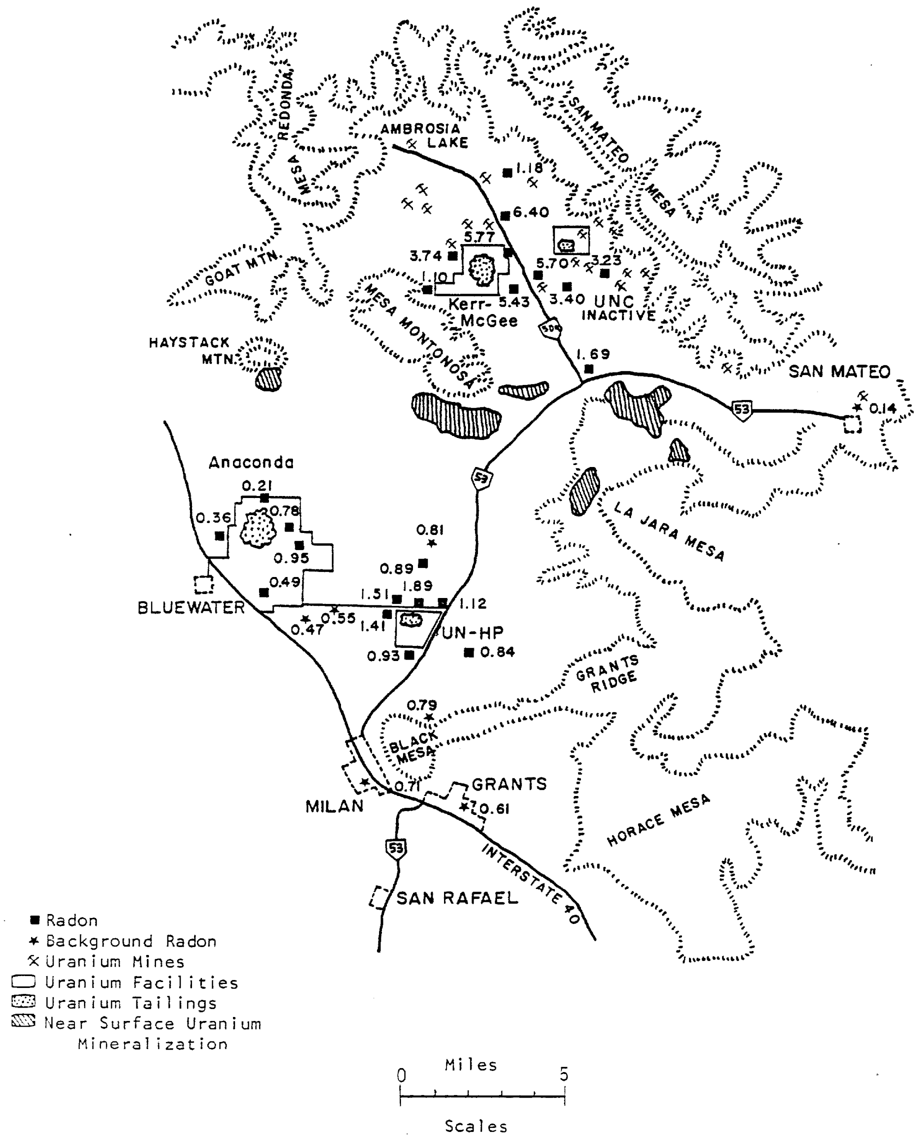


Figure 3.3 Second Year Radon Averages By Station

Homestake Mining Co.
DP-725

Effluent Management Facilities

Waste Management Concerns:

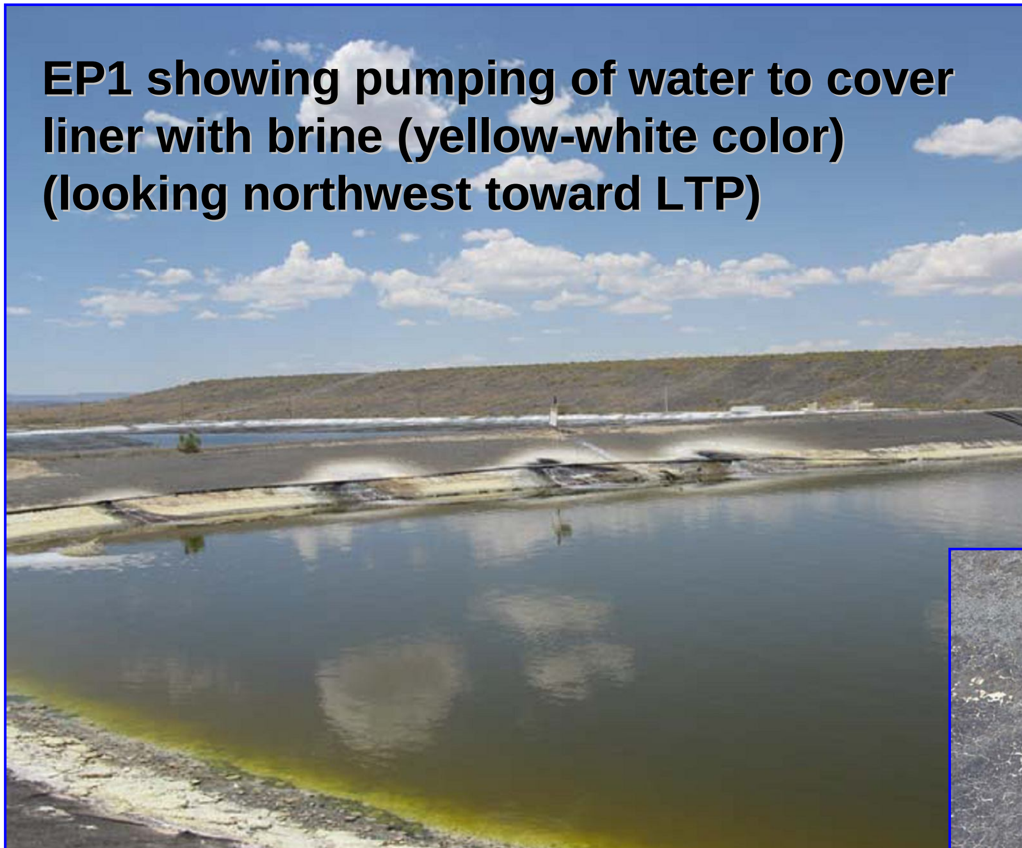
Liner Integrity

Liner exposure to weather and sludge

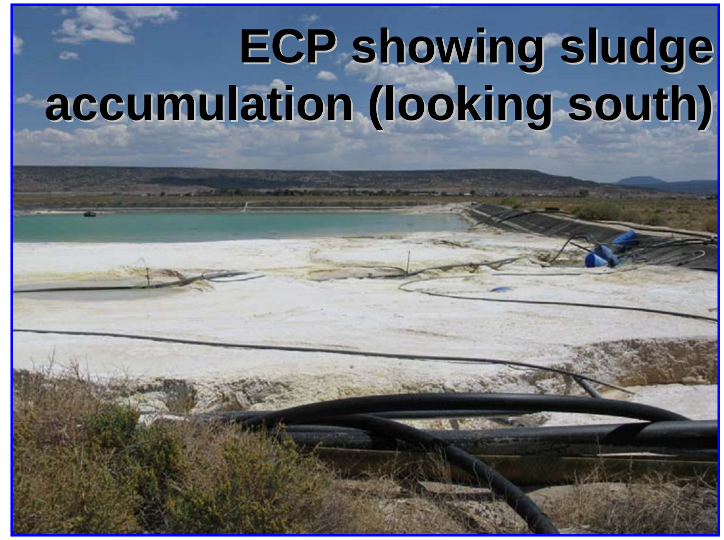
(April 2007)

Liner exposure to salinity and weathering, June 2008

(from USEPA RSE-I Report, Dec. 2008)



EP1 showing pumping of water to cover liner with brine (yellow-white color) (looking northwest toward LTP)



ECP showing sludge accumulation (looking south)

Right: EP2 liner showing effects of exposure to air and sun

Homestake Mining Co.
DP-725

Effluent Management Facilities

Waste Management Concerns:

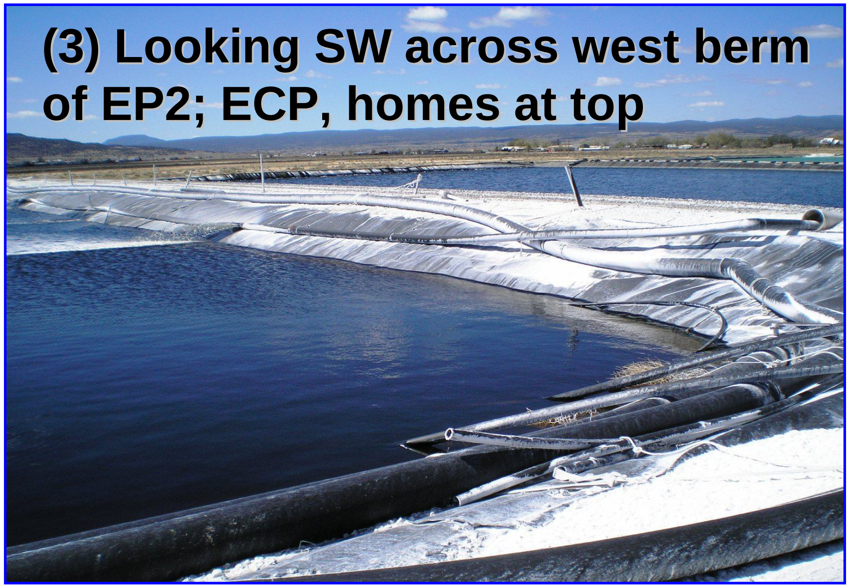
Effluent Spraying

Effluent Spray on EP1, April 2004

(Large Tailings Pile, center-right)

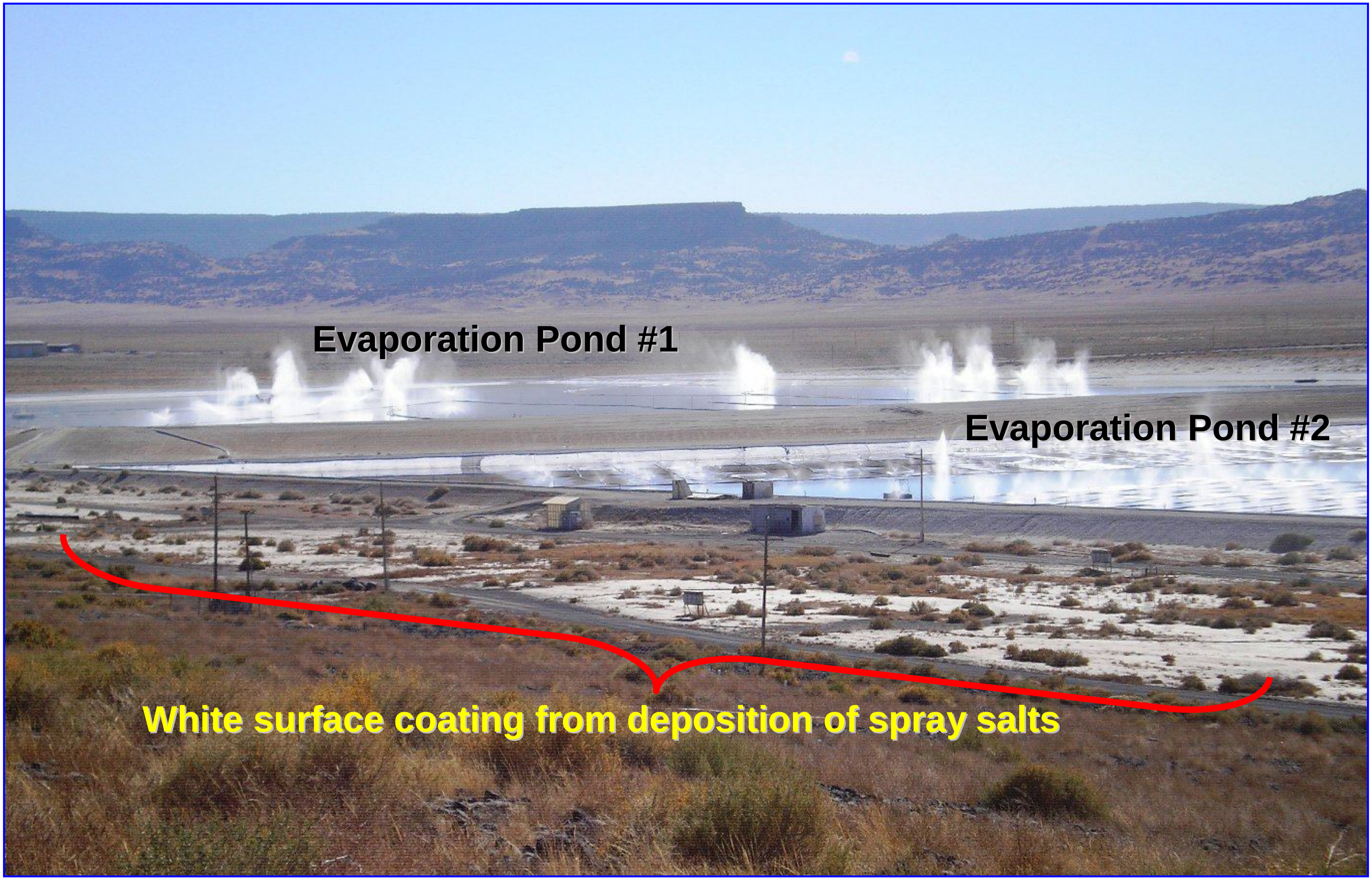
Spraying effects, April 2007:

White salt deposits on berms of EP2



Sprayers on EP1, EP2

October 2007



Effluent Spray over EP1, April 2009

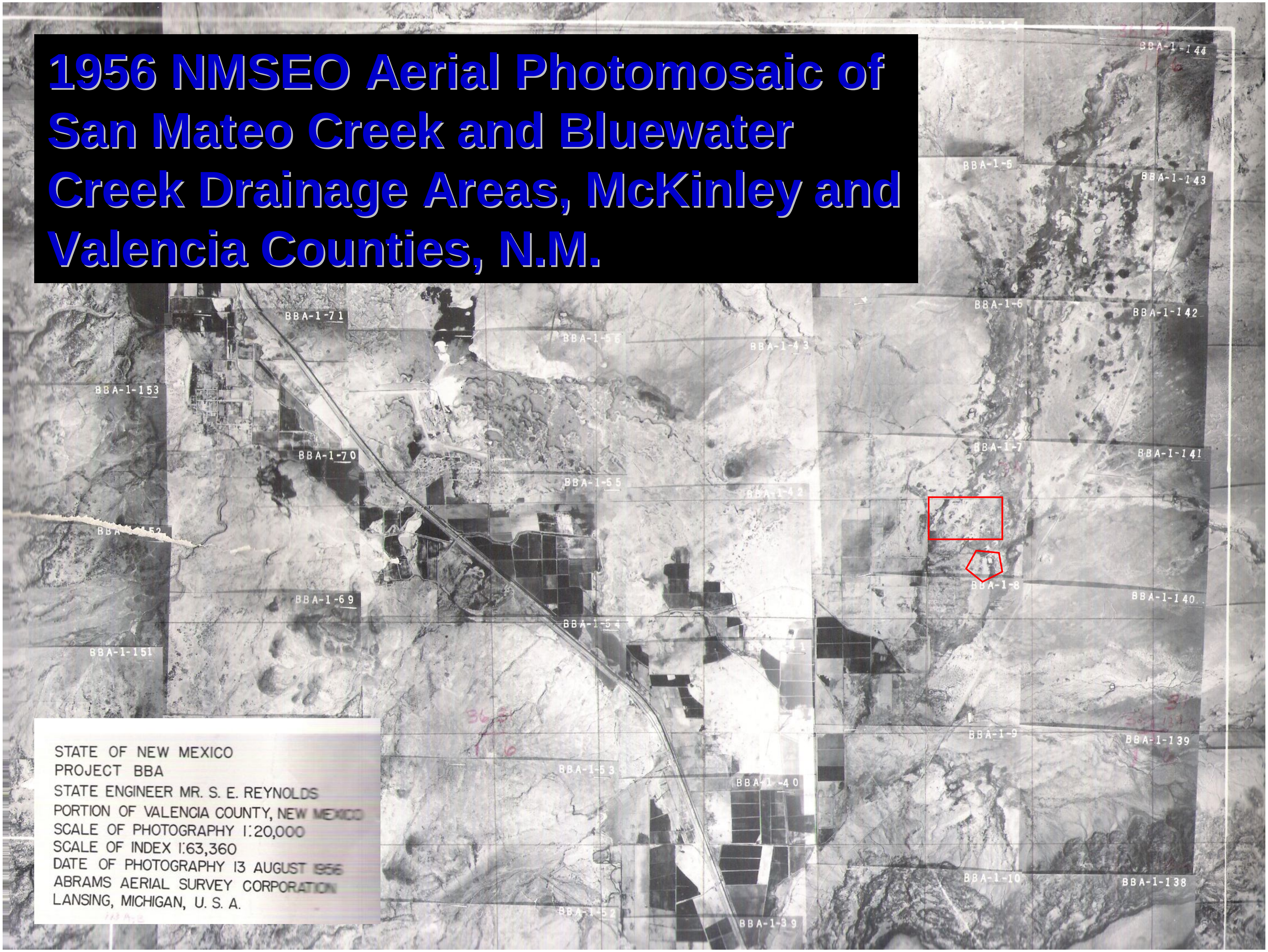
(showing eastern fence line and eastern berm of Small Tailings Pile)

Homestake Mining Co.
DP-725

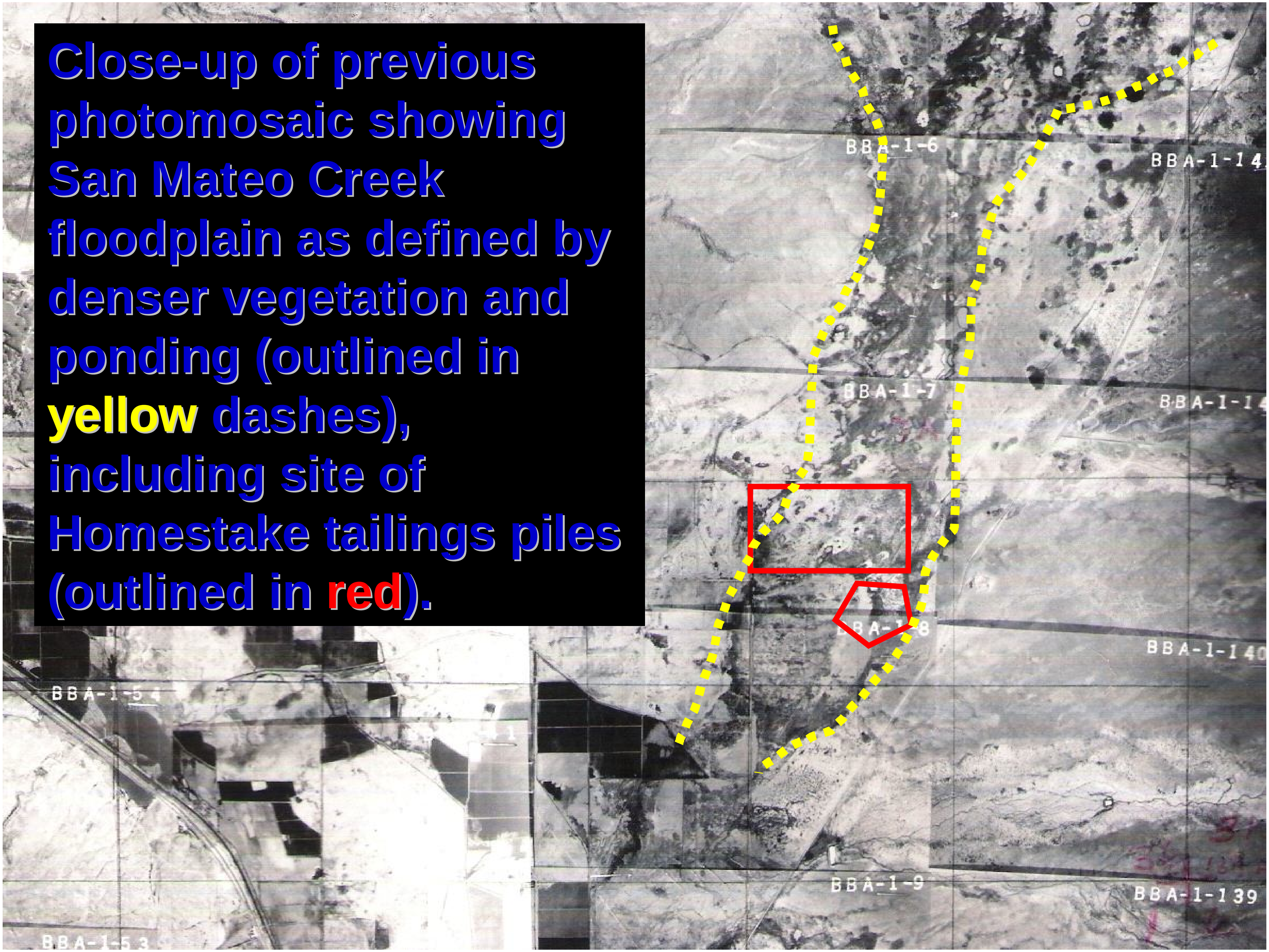
Effluent Management Facilities

Facility Siting Concerns

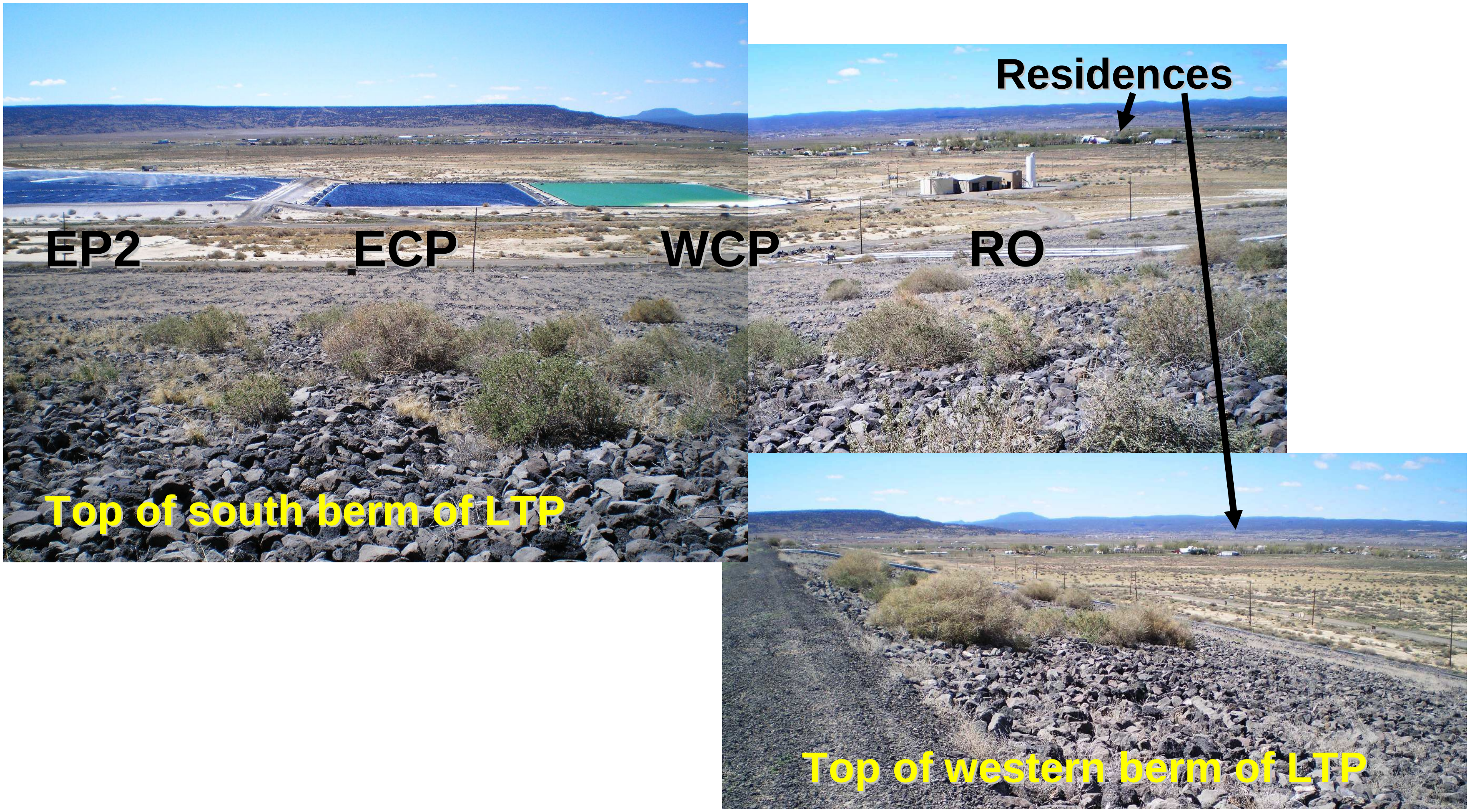
1956 NMSEO Aerial Photomosaic of San Mateo Creek and Bluewater Creek Drainage Areas, McKinley and Valencia Counties, N.M.



Close-up of previous photomosaic showing San Mateo Creek floodplain as defined by denser vegetation and ponding (outlined in yellow dashes), including site of Homestake tailings piles (outlined in red).

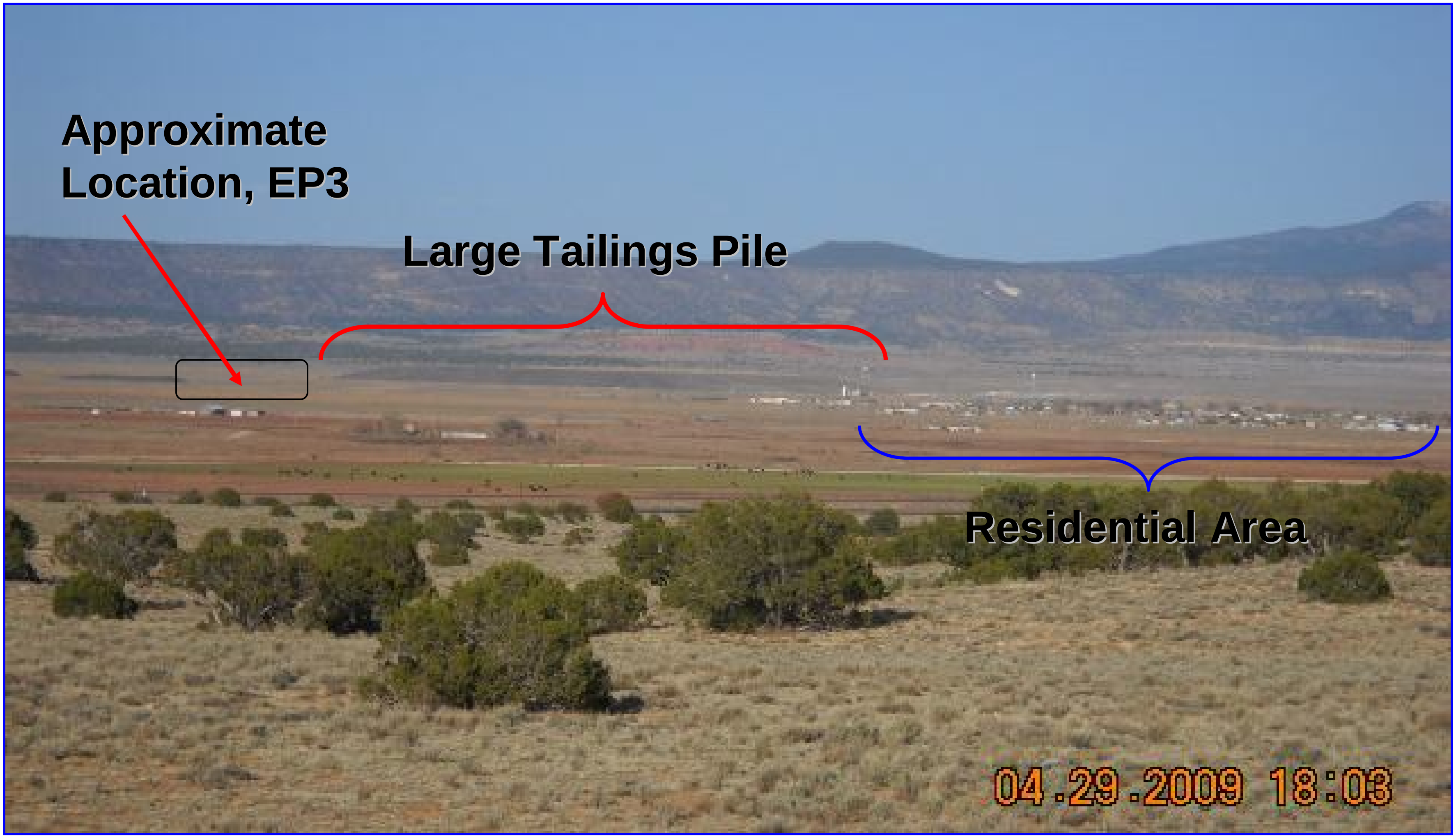


Proximity of Waste Management Units to Residential Areas



View of Homestake Mill Tailings Site and Residential Areas, April 2009

(Mt. Taylor in right background)



Technical Assistance Services for Communities
Contract No.: EP-W-07-059
TASC WA No.: R6-TASC-002
Technical Directive No.: R6-Homestake Mining-03

Observations and Recommendations Regarding the June 18, 2010 Addenda to the Draft Focused Review of Specific Remediation Issues for the Homestake Mining Company (Grants) Superfund Site, February 2010

July 22, 2010

I. Introduction

A. This document provides the Bluewater Valley Downstream Alliance (BVDA) with comments on two addenda to the U.S. Army Corps of Engineers' (USACE) "Draft Remediation System Evaluation (Supplement) for the Homestake Mining Company (Grants) Superfund Site, New Mexico" (DRSE, 2010). One addendum, referred to in this document as the "Evaporation Addendum," addresses new Remediation System Evaluation (RSE) Team calculations regarding evaporation rates, evaporation pond capacities and possible changes in the current ground water remediation system at the Homestake Mining Company (HMC) site. The second addendum, the "Carbon Footprint Addendum," discusses options that involve moving the existing HMC tailings piles to achieve ground water remediation and site decommissioning and decontamination under both federal and state authorities. These addenda were provided by the RSE Team to stakeholders by e-mail on June 18, 2010.

B. The two addenda are understood to be revisions of the DRSE Report, prepared by the RSE Team on its own initiative to revise its previous calculations on evaporation rates (and evaporation capacity) and the "carbon footprint" of a tailings relocation option, and in part as response to comments from some stakeholders (including BVDA) in the RSE process.

Further clarity regarding the RSE Report process is needed following submittal of these addenda. It is recommended that the U.S. Environmental Protection Agency (EPA) and USACE provide clarification on next steps for the RSE Report. Possible options include:

1) A second draft RSE report will be issued for comment once the RSE Team and stakeholders have had a chance to review and respond to comments on the addenda.

2) The RSE Team will issue a final report, responding not only to comments on the addenda, but also to comments received in April and May 2010 from various stakeholders.

3) Some other variation on the path to a final RSE Report.

It is a concern that there have been no RSE Team responses to the May 6, 2010 TASC comments that addressed: (1) elements of the DRSE Report that concerned the overall effectiveness of the ground water remediation system; and (2) deficiencies in the current air monitoring program for radionuclides, particularly radon.

II. General Comments on the June 18th Addenda

A. When read in tandem, the two addenda and the DRSE Report identify many unresolved issues regarding both the effectiveness of the *current* ground water remediation program and the *long-term* management of a fully remediated site. To resolve the difficult issues related to current performance and long-term management, the RSE Team should identify the full range of options in both areas and the range of additional actions and investigations to define an optimized path forward for remediation at the HMC site. By treating these portions of the remediation system optimization separately, the tailings relocation option (or options, given there are several options that have not been considered by the RSE Team, as outlined below) is dismissed prematurely prior to demonstration of an effective ground water remediation system and without the level of scientific evaluation merited by the complex and challenging conditions and the 50-year history of ground water contamination at the HMC site.

B. To provide for more thorough consideration of remediation and long-term management options at the HMC site, the RSE Team should evaluate whether the existing EPA -Nuclear Regulatory Commission (NRC) Memorandum of Understanding (MOU) provides an effective mechanism for implementing remediation optimization. This MOU apparently supplanted the need for a Remedial Investigation/Feasibility Study (RI/FS) under authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for the “ground-water operable unit” in the mid-1980s. Absent an RI/FS, the MOU mechanism should be reviewed to ensure that all feasible options for improving and expediting ground water remediation in the short term and long-term site management and rehabilitation are considered.

C. When considered together, the contents of the addenda and the DRSE report would have major implications for the scope and form of the HMC site’s remediation system if they were considered at the level of detail appropriate for review of alternatives for the “Corrective Action Plan” (CAP) under review by the NRC since 2006. If the DRSE Report was considered as a set of substantive comments on the proposed CAP license amendment currently under review by the

NRC, or on the DP-200 application currently under review by the New Mexico Environment Department (NMED), implications of its suggestions and recommendations regarding regulatory actions affecting the site could be thoroughly considered.

D. Since the remediation system evaluation or optimization process under CERCLA is a science-based initiative based on sound technical approaches, and not a regulatory-based process, serious consideration of alternatives for the long-term remediation of the site and the area's ground water must be completed in the context of the existing NRC license, NMED's ground water discharge permit, or both concurrently. For these reasons, the RSE Team should specify in the final RSE Report that the identified optimization opportunities should be subject to a full-scale analysis as corrective action options, including consideration of all options for tailings removal and relocation. In addition, the RSE Team should specify that this analysis should be conducted under authority of the Atomic Energy Act and the National Environmental Policy Act at the federal level and the New Mexico Water Quality Act at the state level. It is suggested that the optimization enhancements identified by the RSE Team be considered as modifications to the Homestake CAP currently being reviewed by the NRC as a license amendment. If this is done, the RSE Report could provide a basis for a "new, hard look" as it provides substantial new information not available during the review of previous license amendments.

III. Evaporation Addendum

A. In the Evaporation Addendum, including the brief discussion of the "Combination of Evaporation Capacity with other Waste Minimization Optimizations," the RSE Team offers a range of proposed evaporation and treatment scenarios, including elimination of future pond capacity and active (spray) evaporation. These combinations of optimization strategies have the potential to significantly modify current and future remedial operating conditions at the HMC site.

B. The RSE Team also offers suggested improvements in the existing treatment works that could eliminate the need for additional evaporation capacity. Key improvements suggested include:

- Identifying the basis for significant modifications to optimize performance of the evaporation/spray/treatment system.
- Substantially reducing or even eliminating the tailings flushing system.
- Considering installation of a subsurface slurry wall around the large tailings pile.

Unfortunately, the RSE Team's recommendation to eliminate further consideration of the only source control option available at the site — the relocation of tailings and subsoil to a prepared site — removes an important, if not the most important, optimization strategy from further consideration. The RSE

Team should suggest a detailed review of the full range of long-term management options, including both on-site containment and off-site disposal, in the context of remediation system optimization.

C. The “Combination of Evaporation Capacity…” analysis appears to conclude that additional ponds are superfluous if the treatment plant is optimized. The Evaporation Addendum identifies two approaches: (1) using a second high-pressure reverse osmosis (RO) line; and (2) routing tailings and toe drain water to the RO system for treatment. These changes would result in treatment capacity gains and eliminate the need for additional ponding. These changes would rely on proven technology, such as the high-pressure RO line, and replicate systems already on site.

D. Conducting a pilot test, if needed, before incorporation of the two identified treatment system enhancements, as proposed by the RSE Team, should be incorporated into existing performance requirements for the NRC license and the DP-200 NMED ground water discharge permit to supplement and/or optimize the site’s Corrective Action Plan.

E. The “Combination of Evaporation Capacity” analysis does include significantly expanding the capacity of the RO treatment system as a remediation system optimization option. The RSE Team should assess whether the RO plant capacity could be raised to take full advantage of all evaporation pond capacity on site. If the evaporations ponds can evaporate additional flow, the RSE team should evaluate combinations that include expanded RO treatment capacity. Expanded RO treatment capacity could allow for increased extraction of fluids containing contaminants of concern, particularly if the current system is revised to reduce the treatment burden associated with flushing flows derived from both injection and extraction.

F. The discussion of evaporative capacity and treatment options should include a discussion of the disposition of contaminants of concern that are managed by those systems, since they are the focus of the remediation effort. The RSE Team should suggest that the remediation system include identification of the distribution of radionuclides, metals and gross constituents in fluids and sludges that are stored in the four existing ponds and in precipitates deposited on and around the berms of the ponds.

G. The DRSE recommended discontinuance of tailings flushing because it adds significant volumes of fluids to the system without demonstrating concomitant progress toward meeting ground water remediation action levels. The Evaporation Capacity Addendum notes the advantages of reducing wastewater volumes entering the treatment and evaporation system. Another advantage of ending flushing that is not recognized in the addendum is that Homestake would no longer need to keep the top of the Large Tailings Pile (LTP) open to facilitate operation of injection and collection wells associated with the flushing practice.

Since Homestake has stated previously that 98.6 percent of radon emitted from the facility is from the LTP and Small Tailings Pile (STP), covering the top of the LTP with a final radon cover could substantially reduce radon emissions and resulting radiation exposures to local residents. The final RSE should suggest that once flushing is terminated, Homestake proceed expeditiously to cover the top of the LTP. (Installing the final radon cap would not preclude relocating the tailings if that option is implemented as discussed below.)

IV. Carbon Footprint Addendum

A. The Carbon Footprint Addendum dismisses the tailings removal option based only on costs and carbon emissions, with no consideration of the long-term environmental performance goals for the site. This narrow "energy cost only" view fails to consider long-term objectives for the HMC site — ground water remediation and reduction of potential health risks for nearby residents. The addendum appears to provide only a comparison of energy budgets for three environmental management options at the site, one of which is continuing the current remediation system, with all of its previously identified shortcomings.

B. The Carbon Footprint Addendum should be incorporated into a section of the final RSE Report related to long-term environmental management. The RSE Team should encourage retention and refinement of the tailings relocation option for analysis beyond its brief and incomplete consideration in the addendum.

C. In the Carbon Footprint Addendum, the RSE Team offers a comparison of alternatives that are not evaluated using comparable types of information. The alternatives are: (1) the current system; (2) tailings and subsoil excavation and off-site disposal; and (3) slurry wall construction. The addendum attempts to compare and contrast information drawn from the fully engineered and permitted tailings relocation program for the Moab, Utah, tailings with few site-specific considerations and the sparsest of conceptual models for the "current system" and "slurry wall" remediation options.

   a. The "current system" as conceptualized by the RSE Team would appear to be different from the "current system including flushing," which the RSE Team projects will not meet the goal of attaining NRC-approved "action levels" for uranium and other contaminants in the alluvial aquifer by 2017. It should also be noted that the "current system" includes the use of spraying to enhance evaporation rates, a practice to which the local community has repeatedly objected, based not only on potential spray impacts on air and land quality and radiation exposures, but also on their repeated observations of sprays and spray particulates drifting into the adjacent communities.

b. The conceptual model for the single “new technology” option, the slurry wall alternative, may prove valuable, but there is no performance record applicable to the HMC site or a site of analogous proportions and conditions. The RSE Team should examine the slurry wall system installed at the IMC Fertilizer, Inc., Gypsum Stack Expansion in Polk County, Florida (see: http://www.ardaman.com/award2.htm). This system, which includes 20,000 linear feet of vertical cutoff walls up to 110 feet deep, is less than 20 years old and is the only example of currently implemented slurry wall technology that could be identified online. Notably, the Carbon Footprint Addendum does not use the IMC slurry wall system or any other real world example of a slurry wall system, as a model for comparison and contrast with facilities and hydrologic conditions at the HMC site.

c. The RSE Report should suggest that EPA, HMC, NRC or NMED gather data on the full cost of perpetual pump-and-treat systems with and without slurry walls. This approach would provide for a full-scale comparison of costs and benefits with the site-specific tailings removal option before that option is eliminated.

D. A significant portion of the energy and safety costs associated with the tailings relocation option is associated with the transport of tailings and subsoil to an alternative site outside of the San Mateo Creek floodplain. Identification of a site, or sites, closer to the existing tailings facility and thorough consideration of transportation alternatives (e.g., a slurry pipeline with wastewater recycling, conveyor-belt systems, or rail transport) may allow costs identified for the tailings relocation scenario to be significantly reduced.

Truck driver and equipment operator jobs are of fundamental importance to communities with a history of mining activity. Both are associated with safety risk, based on miles logged on the equipment. Employment opportunities offered by tailings removal may represent the largest number of local jobs available in the uranium industry for many years unless and until a new uranium mill is constructed to process ore from the hard rock uranium mine proposals in the Mt. Taylor area.

As a point of comparison, the potential employment opportunities associated with tailings relocation should be recognized for the substantial personal, corporate and governmental income it could generate, and for its potential to add value to the local economy by removing a contaminant source from a floodplain upstream of a growing community. As it now stands in both the DRSE Report and the addenda, the relocation option is viewed only as a set of safety risks and carbon emissions, with no other attributes.

E. The RSE team offers a set of important but arbitrary assumptions that are heavily weighted in favor of the unproven pump-and-treat and slurry wall remedies. Those assumptions allow for a 75-88 percent reduction in additional pump-and-treat technology and operating costs for a slurry wall over a 50-75 year period, but do not indicate whether applicable standards will have been met or pre-existing ground-water quality restored through the use of these remediation methodologies. The failure to consider full-scale, long-term management costs for the "current system" and slurry wall alternatives compared with tailings relocation gives those options an unwarranted advantage that is not supported by the performance of those technologies.

F. Long-term management options critical to the remediation of the HMC site need to be more fully examined for each remediation option, including the assumptions used in the analyses.

   a. The assumptions of the Carbon Footprint Addendum should be modified to extend the active life of the HMC site's proposed pump-and-treat system and slurry walls to a reasonably long period, specifically "up to 1,000 years, to the extent reasonably achievable, and, in any case, no less than 200 years," as required in 10 CFR 40, Appendix A, Criterion 6(1)(i), the long-term performance standard set out to comply with the Uranium Mill Tailings Radiation Control Act of 1978, which the U.S. Department of Energy (DOE) must apply to the HMC site if and when current site remediation standards are attained and the site is deeded to DOE.

   b. The current remedial system at the HMC site has not been shown to be effective enough to meet projected performance milestones identified by HMC and regulatory agencies, even after more than 30 years of active remediation conducted by a site owner with the capacity to modify pumping, active evaporation and treatment activities. No slurry wall examples are referred to by the RSE Team to support a major drop-off in slurry wall costs over a 50-75 year period, much less characterization of the effectiveness of a slurry wall to meet environmental standards.

   c. The DRSE Report attributes a long-term lack of success to the site's current remediation system, notably the flushing program that the RSE Team recommends for discontinuance, when compared with attainment of ground water remediation goals. No effort is made in the Carbon Footprint Addendum or other portions of the DRSE Report to demonstrate any long-term performance attributes of a slurry wall system.

   d. The lack of success in attaining remediation, including NRC-authorized "action levels," is reflected in the Concentration Trends spreadsheet posted to the RSE website by the RSE Team on March 18, 2010, and discussed, in part, in the previous TASC report, "Observations and Recommendations Regarding the Draft Focused Review of Specific

Remediation Issues for the Homestake Mining Company (Grants) Superfund Site, February 2010 – Ground Water Considerations, May 6, 2010." The concentration trends compiled by the RSE Team from HMC site data show little, if any, reduction in uranium concentrations across large portions of the site, including (as identified on the tabs of the Concentration Trends Spreadsheet) the west, north and south sumps, the NW, NE, SE and SW tails, and wells S2 AND B4. Those locations are areas not affected by the dilution "plumes" associated with the injection well systems, which so heavily influence Monitoring Well X, as discussed in the May 6, 2010 comments on ground water aspects of the DRSE Report.

G. If the RSE Team recognizes the lack of demonstrated long-term success with the current remedial system and the lack of any demonstration of slurry wall performance over the long-term, then the tailings relocation option remains the only remedy that can attain clean-up standards at the site, much less attain clean-up standards without long-term active monitoring and maintenance. The tailings relocation option is the only option that offers the possibility of a final remedy for decontaminating ground water by removing the source of the pollution — the unlined tailings piles. The current system and slurry wall options are essentially treatment methods that would operate in perpetuity.

H. Some of the long-term environmental management bonds for New Mexico facilities include replacement of pumping systems for perpetual pump-and-treat programs, such as at the Chevron-Questa molybdenum operations. Similar perpetual treatment costs can be expected if some variation on the current remedial system or the slurry wall system is eventually used instead of the tailings relocation option.

I. Retention of the tailings relocation option will allow for cost and performance estimates for that option to be optimized and will allow for consideration of appropriately long-term (hundreds to thousands of years) costs and performance estimates for the other two environmental management scenarios, the current system and slurry walls, to be assessed at a detailed level incorporating conditions in and around the HMC site.

J. A new site for permanent disposal of the tailings would have to meet current NRC and NMED standards, including below-grade disposal in multi-barrier trenches, placed in a geotechnically suitable location removed from human settlements (see 10 CFR 40, Appendix A, Criteria 1, 3, 5 and 6, among others). Accordingly, the tailings relocation option should remain as a primary option for long-term management of HMC site tailings, unless and until an effective remedy is demonstrated.

K. Funding the life-cycle cost of remediation at the HMC site has been and will continue to be a significant public cost. Accordingly, consideration should be given to use of the site for renewable energy generation to offset carbon costs and fund remediation and local employment.

V. Need for a Long-Term View of Local and Regional Ground Water Protection

A. The two RSE Report addenda continue to emphasize short-term (50-year or less) conditions in San Mateo Creek, including the HMC site, rather than longer-term (100-year and beyond) flow conditions in which historic flows may be restored. The HMC site does not exist in isolation from the historical surface and ground-water flow patterns of the watershed around it

B. The historic flows in San Mateo Creek, including, but not limited to, flows from proposed uranium mine dewatering projects (see the Roca Honda Mine application: http://www.emnrd.state.nm.us/MMD/MARP/permits/MK025RN.htm; click on "Mine Operations Plan") will provide a perpetual source of upstream flow, both surface and subsurface, into the HMC site without requiring an extensive, perpetually-endowed pumping effort.

C. The historic flows of Bluewater Creek, retained by the rapidly aging Bluewater Dam in the Zuni Mountains, are likely to return to the Bluewater Valley eventually and also provide a perpetual source of upstream flow.

D. Management of environmental management activities on site continues to assume that the small and large tailings piles in the floodplain of San Mateo Creek near its confluence with Bluewater Creek will continue to be permitted and maintainable as permanent disposal sites. These piles are not lined, will take many more years to dry out before they cease to be sources of fluid infiltration to the alluvium and underlying Chinle bedrock, and, in the case of the Small Tailings Pile, will be the final disposal location for solid wastes associated with the current remediation system.

E. Management of the thousands of acre-feet per year of water that flow through the area affected by the HMC site tailings continues to evolve. The RSE Team should consider much longer-term conditions than the 50-year life of HMC in the Bluewater Valley. The RSE Team, and applicable regulatory programs, should aim to restore natural ground water and surface water flow conditions without active maintenance as the appropriate environmental conditions if and when standards are attained in areas affected by HMC operations. Final conditions should not rely on deed restrictions and temporary provision of alternative water supplies.

E^2 Inc. Project Manager and Work Assignment Manager
Terrie Boguski, P.E.
913-780-3328
tboguski@e2inc.com

E^2 Inc. Work Assignment Manager (beginning July 23, 2010)
Eric Marsh
512-505-8151
emarsh@e2inc.com

Wm. Paul Robinson and Chris Shuey, TASC Subcontractors
Southwest Research and Information Center
P.O. Box 4524, Albuquerque, NM USA 87196
505-262-1862
sricpaul@earthlink.net, sric.chris@earthlink.net

E^2 Inc. Program Manager
Michael Hancox
434-975-6700, ext 2
mhancox@e2inc.com

E^2 Inc. Director of Finance and Contracts
Briana Branham
434-975-6700, ext 3
bbranham@e2inc.com

E^2 Inc. TASC Quality Control Monitor
Paul Nadeau
603-624-0449
pnadeau@e2inc.com

July 23, 2010

Ms. Kathy Yager
U.S. Environmental Protection Agency
Technology Innovation and Field Services Division
11 Technology Drive (ECA/OEME)
North Chelmsford, MA 01863

Dear Ms. Yager,

Bluewater Valley Downstream Alliance (BVDA) submits the following comments on the Army Corps of Engineers June 18, 2010 Addenda to the Feburary 2010 Draft Remediation System Evaluation for the Homestake/Barrick Gold Mining Company Superfund Site in Milan, N.M.

1. The Large Tailings Pile restricts a major flood plain. It is unlined and will leak contaminants in perpetuity.
2. The Large Tailings Pile as well as the other tailings pile and waste from current evaporation ponds must be removed to a safe, permanent storage site. No other alternative provides a full remedy, protective of future generations. We hereby request the EPA to extend the USACE's scope of work to include a serious and full consideration of removal and long-term storage of the tailings piles and contamination wastes.
3. If Homestake/Barrick's expert is correct and most of our radon exposure comes from the tailings piles and not the ponds, the tailings piles need interim cover to reduce radon exposure to our community until they are removed.
4. Clearly, Homestake/Barrick Gold must increase RO capacity to enable a full cleanup of contaminated groundwater. The RO process must be adequate to eliminate the need for spraying, which BVDA continues to oppose because it exposes the community to radon and has never been confined to pond berms as aerial photos and community experience confirm.
5. BVDA assumes and expects that the optimization identified by the RSE process will become the basis of a more complete review of Homestake/Barrick Gold's Corrective Action Plan by the NRC under the Atomic Energy Act and the National Environmental Policy Act and that the NMED will use it in future Discharge Plans under the NMWQA.
6. Time is of the essence. Our community has suffered long enough and it is no longer sufficient for the NRC to simply allow another five years for cleanup. This has been the policy for too long and has allowed Homestake/Barrick Gold to evade their responsibility with inefficiency and delays. New cleanup goals are needed and Homestake/Barrick Gold must commit the resources to solve this contamination problem.

BVDA hopes and expects there will be further opportunity to comment on the RSE report before it is finalized and made public. BVDA looks forward to learning soon how the Nuclear Regulatory Commission and Homestake/Barrick Gold plan to implement RSE recommendations once the report is finalized.

Sincerely,

Candace Head-Dylla,
for Bluewater Valley Downstream Alliance
#6 Ridgerunner Rd.
Grants, NM 87020
505-401-4349; cuh148@psu.edu

cc: Attached list

Congressman Martin Heinrich
20 First Plaza NW, Suite 603
Albuquerque, NM 87102

Congressman Ben R. Lujan
811 St. Michael's Drive Suite 104
Santa Fe, NM 87505

Congressman Harry Teague
Los Lunas Office
3445 Lambros Loop NE
Los Lunas, NM 87031

Senator Jeff Bingaman
625 Silver Avenue, SW, Suite 130
Albuquerque, NM 87102

Senator Tom Udall
Albuquerque Plaza
201 3rd St. NW,
Suite 710,
Albuquerque, NM 87102

NEW MEXICO
ENVIRONMENT DEPARTMENT

Ground Water Quality Bureau

1190 St. Francis Drive, P. O. Box 5469
Santa Fe, NM 87502
Phone (505) 827-2900 Fax (505) 827-2965
www.nmenv.state.nm.us

BILL RICHARDSON
Governor
DIANE DENISH
Lieutenant Governor

RON CURRY
Secretary
SARAH COTTRELL
Deputy Secretary

July 19, 2010

Ms. Kathleen Yager, EPA
U.S. Environmental Protection Agency
Technology Innovation and Field Services Division
11 Technology Drive (ECA/OEME)
North Chelmsford, MA 01863

RE: Review comments on "Focused review of specific remediation issues" (February 2010 draft); new appendix on evaporation pond capacity, and new section 4.4.4 "Removal of tailings"

Dear Kathy:

The New Mexico Environment Department (NMED) herein submits comments on the new appendices to the Remedial System Evaluation (RSE) report captioned above.

Evaporation pond capacity

1. Elements of the "proposed pumping scenario" should be briefly summarized in this appendix for additional clarity to the reader. From Section 4.1 of the RSE, NMED understands that the primary element of this scenario is discontinuation of current flushing for the Large Tailings Pile.
2. The projected effluent rate of the toe/tailings drain collection system (65 gpm [Table 5]) under the proposed pumping scenario inexplicably is indicated to be higher than that of the current pumping scenario (61 gpm [Table 4]). Although the rate under the proposed pumping scenario might equal that of the current pumping scenario temporarily, the RSE states that the rate from this source should decrease significantly with time (Section 4.1, p. 19). Therefore the analysis presented in Tables 2 through 7 should be reviewed and modified accordingly to account for this projected decline.
3. The Corps of Engineers' RSE team should consider including an analysis of possible modified evaporation rates or influent rates under implementation of possible modifications suggested in section 5.3, and the consequent effects on the necessary evaporation capacity.

4.4.4 Removal of Tailings (proposed new RSE section)

1. Implementation of a slurry wall, as included in Table 4, would necessitate continuation of ground water extraction in perpetuity; it is unclear what time period is modeled in the calculation that is presented in Table 4.

Please contact David L. Mayerson at (505) 476-3777 or Jerry Schoeppner at (505) 827-0652 if you have any questions.

Ms. Kathleen Yager, EPA
RE: Review comments on "Focused review of specific remediation issues" (February 2010 draft); new appendix on evaporation pond capacity, and new section 4.4.4 "Removal of tailings"
July 19, 2010

Sincerely,

David L. Mayerson
Superfund Oversight Section

Jerry Schoeppner
Mining Environmental Compliance Section

Ground Water Quality Bureau
New Mexico Environment Department

copies: Mr. Sairam Appaji, EPA

HMC 2010 correspondence
NMED/GWQB/SOS July 2010 read file

Homestake Mining Company Comments on Draft Final Report submitted December 9, 2010		
Cmt #	**Comment from HMC**	**Response**
1	The flushing program is proactive at accelerating the removal of uranium mass from the pile, allowing for its capture and treatment and preventing the long-term drain down of continuously elevated concentrations of uranium over the foreseeable future. Ending this program is not warranted and would be short-sighted in the absence of a better approach because it would prolong the environmental restoration without any means of controlling the source of uranium to groundwater.	We understand HMC's position. We acknowledge that there has been a significant benefit to the flushing program, and the mass removed from the pile has been significant. Still, HMC has not adequately addressed the concern regarding the certainty in any conclusions based on data from monitoring points with very long screens. See response to summary comment 2.
2	The rebound of uranium into tailings water and subsequent recontamination of the alluvial aquifer is in fact being mitigated by the flushing program. The flushing program is both removing uranium mass and establishing geochemical conditions in the LTP that lead to greater stability with respect to immobilized uranium (*e.g*., lowered ionic strength, moderate pH, and lowered alkalinity). In addition, the geochemical conditions that have been created by flushing may be enhanced through the addition of amendments to the LTP (e.g., phosphate) that serve to further immobilize uranium and "blind-off" any uranium in lower-permeability materials and prevent back diffusion. A relatively limited number of these locations may exist and are currently being evaluated by HMC.	Given that our concern focuses on the likelihood that much of the fluids have not been flushed, one test that would confirm or deny this hypothesis is to conduct a rebound test in part(s) of the pile for some period of time, as suggested in the Recommendations of the Draft Final Report. Such rebound testing must include, in our opinion, new monitoring points with short well screens. We support the proposal to test amendments that would work to further immobilize the uranium, especially if HMC/Barrick can find an economical way to implement such an approach.
3	The recommendation that a pipeline to slurry tailings to a repository that is 20 miles away be considered is overly simplistic and the incomplete analysis that justifies this serves to weaken the merit of the RSE Report. HMC believes that this option would be far from protective of human health and the environment and is technically infeasible as described.	USACE does not support movement of the tailings pile by any means due to the risks to workers and the community, carbon emissions, and the resource impacts. The analysis of the carbon emissions for a slurry transport system was done as a comparison to trucking the tailings to another location. We agree that a number of aspects of a slurry transport system are not specifically included in the analysis or cost estimate. We agree, too, that there will be an impact to ground water resources. A clarification of this fact has been added.
4	The slurry wall is not feasible as described and further evaluation shows that factors such as extreme depth of excavation, inability to create a competent bedrock key, and inability to assure continuity of the slurry wall. Each of these factors taken separately or in combination seriously discounts this as a technology that holds merit at the Grants site.	USACE agrees the slurry wall alternative is not appropriate for addressing seepage through the bedrock aquifer, and the slurry wall depths were estimated based on the depth to top of rock. These assumptions are documented and were the basis for the estimates received from a slurry wall contractor. The contractor indicated that the wall through the unconsolidated materials is feasible to the assumed depths. The estimated costs are certainly approximate. We are not advocating the use of the slurry wall unless economically justified. If one

		hypothesizes a significantly longer duration of pumping than currently planned (as USACE does) the economics of the slurry wall would seem more favorable. The potential incompatibility between the tailings liquids and the slurry is a legitimate concern and a mention about the need to assess the compatibility has been added to the text.
	Comments on previous responses	
	HMC Comment 25: the ACOE states concurrence with the comment pointing to the inaccuracy of the statement that irrigation water is affecting groundwater through leaching; although the clarification was not made in the revised document.	Correction to section 2.1.4 has now been made.
	HMC Comment 27: the ACOE indicates that the CSM figure descriptions will be clarified to better indicate known sources, however this change was not made in the revised document. In addition, requested changes to the CSM were not made. The mill was not removed as a primary source, and the drinking water pathway for groundwater remains complete.	The CSM figure was revised to clearly show that no known, only potential, release mechanisms existed for the buried mill debris. This is consistent with the circumstantial evidence of a source in that area as described in the response to Comment 4. The drinking water pathway was reevaluated based on an NMED comment (Comment 52) and the 2009 Land Use Review/Survey published by HMC.
	HMC Comment 32: the ACOE indicates that changes will be made to correct the awkward wording relative to groundwater contamination, however this change was not made.	Correction to section 4 has now been made as requested.
	HMC Comment 39: the ACOE "noted" HMC's comment relative to an incorrect citation for a new immobilization technology; however the correction was not made in the revised RSE.	Correction to section 4.4.3 has been made.
	HMC Comment 40: The ACOE indicates that text will be modified to correct the discussion of selenium chemistry, and to correctly indicate that selenium exists as a cation rather than as an anion; this correction was not made in the revised RSE.	The language has been revised to the following: "Although it is feasible to add an additional ion exchange column to remove the molybdenum, no ion exchange resin was found that could reliably remove selenite (SeO_4^{-2} or $HSeO_3^{-}$), which is one of the anionic forms of selenium that may be present in the treatment plant feed. Therefore, this option was eliminated from further consideration."

Homestake Mining Company's Comments on the U.S. Army Corps of Engineers' Focused Review of Specific Remediation Issues: An Addendum to the Remediation System Evaluation for the Homestake Mining Company (Grants) Superfund Site, New Mexico (Draft Final Report, August 20, 2010)

December 9, 2010

Homestake Mining Company of California (HMC) respectfully provides the following comments and concerns relating to the Draft Final Addendum to the Remediation System Evaluation for the Homestake Mining Company (Grants) Superfund Site, New Mexico prepared by the Army Corps of Engineers (ACOE) and dated August 20, 2010.[1]

As a preliminary matter, we recognize that the RSE addresses many of the comments and concerns raised by HMC in comments submitted by HMC on May 7, 2010 in response to ACOE's draft circulated in February of 2010. HMC is appreciative of these changes and of the ACOE's courtesy in providing HMC this opportunity to provide additional comments. However, the current draft RSE appears to have overlooked, or rejected, many of HMC's primary concerns.

Rather than repeating each of the points raised in HMC's comments of May 7, 2010, HMC takes this opportunity to reiterate its most fundamental concerns with the conclusions and recommendations in the RSE.

HMC's primary concerns can be summarized as follows:

- The RSE's recommendation to end the flushing of the large tailing pile (LTP) is premature and should be rejected;
- The RSE reflects fundamental misunderstandings regarding the nature of the tailings material;
- The RSE's suggestion to consider a pipeline to slurry tailings to an engineered repository is inappropriate and should be removed from the report; and

[1] We note that a prior Draft Final Remediation System Evaluation Report dated December 19, 2008 was prepared by Environmental Quality Management under contract with the United States Environmental Protection Agency (USEPA). For the sake of simplicity, the August 20, 2010 Draft Final Addendum will be referred to herein as the "RSE.".

- The RSE's continued inclusion of a slurry wall around the LTP as a viable remedial alternative is ill-advised and should be removed from the report.

1) Flushing of the LTP is effective and must be allowed to continue.

HMC disagrees with the RSE's recommendation to discontinue flushing of the LTP. Significantly, both the Nuclear Regulatory Commission (NRC) and the New Mexico Environment Department (NMED), both of which have long histories with the Site, also disagree with the RSE's recommendation to discontinue flushing.

The flushing program is clearly removing uranium mass from the LTP and remains the best approach for uranium source treatment in order to meet future, long-term sustainable site remediation endpoints. The following figure was presented in HMC's comments on the draft report; additional analysis of this figure shows that the rate of uranium removal and recovery has significantly increased with the full implementation of the flushing program. This recovery rate will continue until reaching the point at which the more permeable pore space has been flushed and uranium concentrations decline.

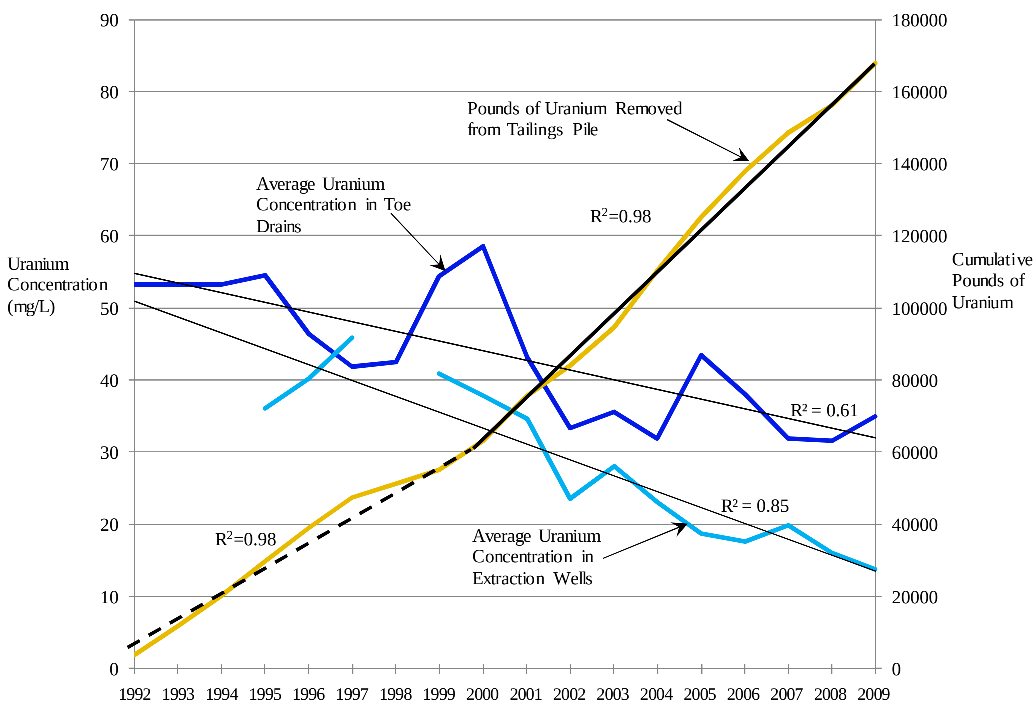


Figure 1. Mass of uranium recovered by the large tailing pile extraction wells and toe drains and decreasing uranium concentrations; dashed line shows the rate of uranium removal (7,500 pounds/year) prior to full implementation of the flushing

program; solid line shows the rate of uranium removal (12,000 pounds/year) with full implementation of the flushing program. Note that the removal rate would have been higher over the last 4 years if extraction could have proceeded at the full system capacity design rate through approval of an additional evaporation pond. This approval was received from NMED in 2010 and the new pond has been constructed and put into service in early December 2010.

The flushing program has made considerable progress, specifically in those areas of the LTP that have been the focus of the program (the low permeability slimes; see Figure 2). These locations are appropriate for an evaluation of the "rebound potential," as suggested by the ACOE (this is discussed further in the following section).

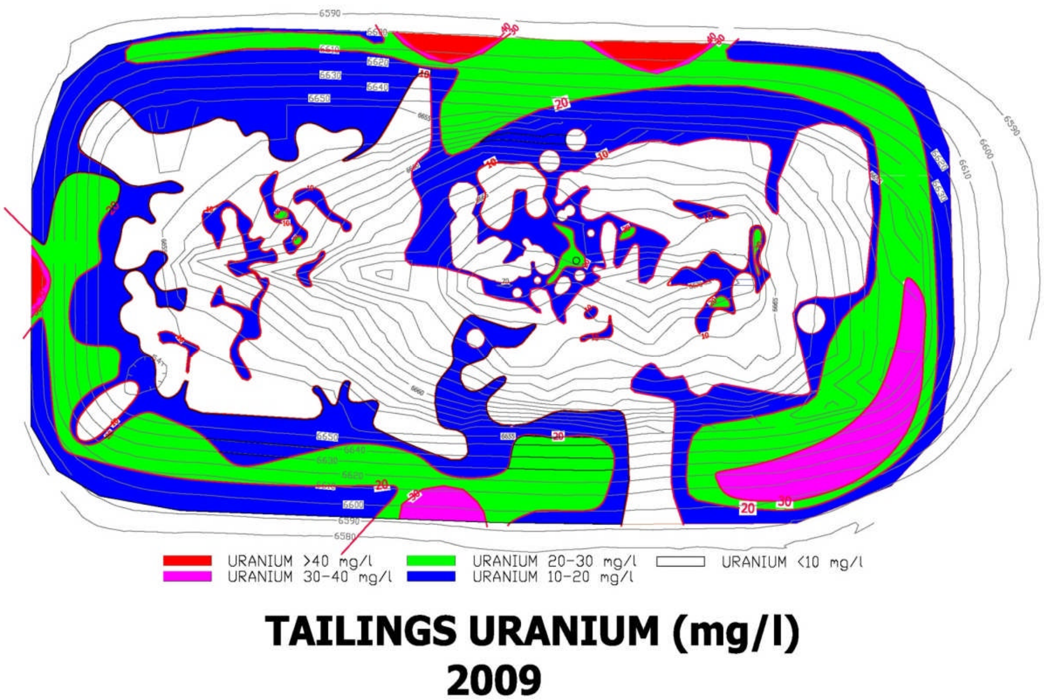


Figure 2. Map of the 2009 uranium concentrations in the pile showing the significant reduction in concentrations resulting from the flushing and extraction program. For 2009, approximately 67.5 percent of the west side slime area has uranium concentrations less than 5.0 mg/L, and 45.5 percent of the same area has concentrations lower than 2.0 mg/L.

The flushing program has also provided opportune locations for an evaluation of the use of phosphate to promote the precipitation and retention of uranium within the LTP. A test of this approach is planned in areas that have achieved moderate ionic strengths, and lowered alkalinity and uranium concentrations.

The RSE expresses concern that HMC may be overestimating the decrease in uranium concentrations. Specifically, the RSE contends that heterogeneity of the tailings material has prevented uniform flushing of the pore fluids. It also contends that because most of the wells have long screened intervals it is difficult to assess representativeness of the samples recovered from wells in the LTP. Finally, because flushing performance has recently diverged from the model prediction, there is concern about the time estimated to achieve flushing performance goals. HMC has long recognized the heterogeneity of the tailings material and the flushing program is designed specifically to address this through closely spaced injection and collection wells in the finest-grained materials (tailing slimes). Preferrential flow paths are likely to be present, however samples recovered from a relatively large number of wells, even with long screens, provides an accurate snap shot of flushing performance. The restoration curves for numerous wells show a first step down in reduction in concentrations due to the more permeable flow paths. We are presently observing the final step in concentration reduction that is due to the slower slime flow paths. HMC has been evaluating tailing heterogeneity and preferential flow through depth-specific sampling and tracer tests as part of a program to evaluate alternatives for groundwater treatment. Divergence between model predictions and flushing performance is due to limited water management capacity and this will be addressed through operational use of EP-3. Rather than propose measures to increase confidence in HMC's reported results, however, the RSE appears to assume that flushing is failing to achieve the desired outcome and therefore should be discontinued.

HMC does not agree with the recommendation to end the flushing program. The flushing program has made significant progress in controlling the source of uranium to the alluvial aquifer, and has effectively moved the remedial system toward meeting remedial end points sooner rather than delaying this further by allowing uranium to gravity drain from the LTP. In addition, flushing has achieved the appropriate geochemical conditions in the LTP so that additional stabilization can be implemented if feasible and appropriate. Ending the flushing program would set the remedial system back and would stop the significant progress that has been achieved, as well as removing the capability to optimize remediation over the near term.

2) After flushing is completed, the LTP is unlikely to be a source of soluble uranium.

The ill-advised recommendation in the RSE to discontinue flushing in the LTP appears to be based on two misconceptions regarding the condition of the fine-grained tailing material in the LTP after the completion of flushing, namely that: (a) soluble uranium will remain in the LTP, and (b) insoluble uranium will reoxidize and become more soluble.

a. Soluble uranium will be removed by flushing.

The RSE concludes that, because 2.6 million pounds of uranium will theoretically remain in LTP after the completion of flushing, flushing will not prevent soluble uranium from migrating from the LTP after flushing is complete. In reaching this conclusion, however, the RSE fails to differentiate between soluble and insoluble uranium—a critical distinction.

Analyses of the milling process and uranium recovery efficiencies show that the majority of the labile uranium was recovered from the ore during processing and that the remaining uranium is present in an insoluble, immobile mineral phase. Soluble uranium in tailings pore water is present in the LTP because it was originally introduced in soluble form during spigoting of the slimes onto the pile, not due to further dissolution of the mineral phase material.

Because further partitioning of uranium into a soluble phase will be minimal, the residual presence of insoluble, immobile mineral phase material in the LTP is irrelevant. This is supported by an understanding of the milling process, and the use of highly alkaline solutions applied to crushed ore to effect maximum dissolution of recoverable uranium (see page 8, HMC, 2010). Therefore, the majority of the uranium remaining in the tailings in LTP is associated with recalcitrant mineral phases.

The RSE also suggests that uranium may diffuse out of the "*many pore spaces that contain fluid that are not significantly participating in the flow if in fine-grained or in dead-end pores*." The concern appears to be that the uranium may diffuse out of these less mobile zones after flushing is complete. The RSE therefore suggests that a pilot test be conducted to evaluate rebound in concentrations in a portion of the tailings pile.

In fact, the flushing program is designed to access these low permeability zones with densely spaced injection and extraction wells and fresh water injection. The injection wells and extraction (collection) wells are numerous and clustered together so as to provide maximum flushing effectiveness in the finest grained tailing material (slimes) where flow between the wells is slowest due to low permeability. The slimes areas are also where dead-end pores will be most prevalent and are purposely targeted in the flushing strategy. In order to verify the efficacy of the flushing program, HMC has planned a rebound evaluation as part of ongoing work in the LTP for the evaluation of alternative groundwater remediation treatment approaches.

b. On-going testing suggests that re-oxidization is unlikely.

The RSE suggests that the flushing of the LTP may have created reducing conditions that reduce the solubility of the tailings material. The RSE therefore expresses concerns that, when flushing is discontinued, re-oxidization may occur, resulting in higher solubility of the tailings material.

Although HMC has considered the potential for re-oxidation of the tailings material, geochemical conditions in the LTP make it unlikely that this will be an issue, specifically because the bulk of the uranium removal is due to flushing and not due to uranium precipitation through reductive processes. In addition, introduction of strong oxidants that access the entire

LTP tailing pore space would be required in order to result in significant concentrations of uranium generated through oxidative rebound. The RSE suggests that additional geochemical parameters be collected in groundwater beneath and downgradient of the LTP and that the role of reducing conditions in the immobilization of selenium be further evaluated. HMC is evaluating the geochemical conditions, and the presence of reducing conditions in the LTP, as a component of the ongoing testing in the LTP.

It is also worth noting that the geochemical conditions enhanced by the flushing program creates ideal conditions for optimization if additional testing were to suggest that rebound may occur. For example, flushing has resulted in decreased concentrations of total dissolved solids (TDS) and moderation of pH (from ~11 down to 8 – 9). These geochemical conditions enable approaches such as the application of chemical amendments (such as phosphate) to be more effective at binding with, and precipitating, soluble calcium and uranium.

HMC does not believe that the recommendation that tailings flushing be curtailed will lead to a better strategy for uranium source reduction in the large tailing pile. The flushing program should continue in order to meet remedial targets. It is also highly unlikely that a significant amount of uranium will be present in a form capable of dissolution upon conclusion of the flushing program, and soluble uranium trapped in immobile pores will not lead to significant rebound.

HMC is in the process of evaluating geochemical conditions in the LTP and the potential for uranium rebound, as well as means to further stabilize those locations that potentially have uranium trapped in slimes. HMC strongly disagrees with the RSE's recommendation and believes that flushing is the most proactive source reduction option currently available and to achieve the remediation targets in a timely manner. As stated previously, we request that this recommendation be removed from the final RSE report. If this recommendation is not removed, EPA should nonetheless reject this recommendation as it will not serve to improve the remedial system at the site.

3) The RSE's suggestion to consider construction of a pipeline to slurry tailings to an engineered repository is inappropriate and should be removed.

Section 4.4.4 of the February 2010 Draft RSE Report presented a tailings removal alternative (excavation, hauling, and disposal) that included relocating the tailings to a disposal cell near the Grants site. The costs for this alternative were scaled based on per cubic yard estimates from a cost analysis prepared for the Moab uranium mill tailings where the Department of Energy is currently relocating tailings. The total cost for relocating the Grants' tailings was estimated to be 2.7 billion dollars and, in light of this cost, the ACOE appropriately concluded that "*relocation of the tailings should not be considered further given the risks to the community and workers and the greenhouse gas emissions that would be generated during such work*".

In spite of the ACOE's own conclusion that removing the tailings should not be considered, the RSE now includes an off-hand discussion of the possibility of transporting the excavated tailings to an engineered repository approximately 20 miles from the Grants site via a slurry pipeline rather than by overland hauling of the materials. The RSE does not present an opinion as to whether this could be a feasible alternative or even whether it should be considered.

The RSE acknowledges that a similar tailing slurry pipeline proposal was made for the Moab site and that it was not accepted, but nonetheless seems to suggest that such a pipeline should be considered. It is troubling to HMC that this suggestion was in the report knowing that it has been previously rejected as impractical at other mill tailings sites.

The cost analysis for the Grants site included scaling costs to those developed for the Moab site in 2003. This cost analysis is overly simplistic and omits several issues that make slurry transport of tailings not viable. These issues are discussed below.

- A large flow rate of 2,000 gpm would be required to slurry the tailings with 1,500 gpm being returned; thus, about 500 gpm of makeup water would be needed. There is no discussion of how to produce and sustain these flow rates from a water rights perspective. It is simply assumed that the water would be available. The likely source of water would be from the San Andreas Aquifer and the large pumping rates may have negative impacts to surrounding groundwater users. This additional water requirement would therefore put significant stress on the aquifer system. In addition, re-saturating, mixing and slurrying the tailings could reverse the improvements in tailings water chemistry that has been achieved by the flushing program.

- Transport of tailings via a slurry pipeline would result in a larger volume of contaminated media than what currently exists at the site. The additional water that is needed for tailing slurry transport, which is initially clean groundwater, would become contaminated. It is not environmentally desirable for a remedial alternative to increase the overall volume of contaminated media.

- There is no discussion in the RSE as to how the tailings would be handled at the repository. For instance, the RSE does not indicate whether tailings would be dewatered and eventually capped or if the repository would be a wet closure. In either case there are no costs developed for capping of the repository or treatment of the tailing water during dewatering. Either of these would incur significant costs that are not accounted for in the analysis and would require significant additional effort to fully evaluate. Further, the slurry pipeline alternative is estimated to take six years to complete, but there is no mention of possible treatment of tailing water or drain down water beyond six years.

HMC believes that the current discussion in the RSE of a possible slurry pipeline is inappropriate and should be removed from the final report. Alternatively, an independent cost analysis should be prepared that fully accounts for potential costs (instead of one based on loosely analogous situations of different size and scope) and the RSE should comment on the alternatives' feasibility and likelihood of success or failure.

4) Replacement of the existing hydraulic barrier with a slurry wall is both impractical and unlikely to provide greater protection

Section 4.4.1 of the RSE evaluates construction of a slurry wall around the LTP as a possible remedial alternative and continues to recommend that HMC evaluate the economics of the slurry wall alternative. As stated in our May 7, 2010 responses, HMC has evaluated the economics and implementability of a slurry wall and found them to be technically infeasible and cost-prohibitive remedial options given the difficulty of construction and likelihood of incomplete isolation or collection of the alluvial groundwater because of the excessive depth of excavations.

However, HMC wishes to emphasize that its objection to a slurry wall is not based solely on economic considerations. HMC also harbors serious concerns with the difficulty of construction and ability to achieve remedial performance objectives based on site geologic and hydrogeologic conditions.

The RSE appears to ignore the specific information provided in our previous responses detailing why a slurry wall would likely fail at the Grants site. The reasons for this are reiterated below:

- *Extreme depth of excavation* – A slurry wall would have to reach depths of approximately 140 feet in some locations around the LTP. The projected maximum depth will actually be much greater if all possible migration pathways are to be cut off. A portion of the LTP is underlain by a mixing zone of saturated alluvium in contact with the Upper Chinle aquifer. The Upper Chinle aquifer dips to the east; therefore, if this possible migration pathway within the Upper Chinle is to be cut off by a slurry wall the depth of the wall along the eastern side of the LTP would be approximately 200 feet (Figure 2-2, HMC, 2003). A slurry wall would become technically infeasible at this greater depth. We know of no successfully constructed slurry walls to this depth, nor does the ACOE provide any information to the contrary.

- *Bedrock key* – An important aspect of the slurry wall is to extend the wall into the underlying bedrock (Chinle shale) to cut off groundwater flow. Excavation into bedrock would be difficult at such depths and may require blasting. It is highly unlikely that that an open trench, or trench filled with slurry, could be maintained while the bedrock is excavated. Traditional excavation equipment cannot perform the rock removal and an excavator cannot be used to rip into the bedrock. The use of chisels, hydromills, and other rock coring equipment may be an option, but the unusually long length of the proposed slurry wall (13,000 ft) would make it very difficult to ensure that the key is continuous. At the projected maximum depth of 140 feet (along the western side of the LTP), it will be difficult to achieve a production rate greater than 5 linear foot of key trench installed to an average depth of 3 feet per day. The key construction alone would take more than 7 years to construct at this rate. The time frame required to complete key construction makes the use of a key impractical; however without a key into the bedrock, the slurry wall will not be effective. If an area of preferential flow develops along the interface of the base of the wall and the bedrock, accelerated groundwater flow velocities could likely cause stability failure within the slurry wall backfill material and loss of containment. On the eastern side of the LTP, it would require that the key penetrate through the shale from 6,500 to 6,320 ft amsl just to reach the top of the Upper Chinle Aquifer, continue through the thickness of the aquifer, and finally into the shale 3 feet for a key. It is doubtful that any equipment can effectively complete that construction task.

- *Slurry wall continuity* – The deeper a slurry wall is the more difficult it is to maintain slurry continuity and thickness. HMC provided guidance on slurry wall construction from EPA in our previous responses, which states that below about 100 feet the verticality and thus the continuity of grout barriers are difficult to control or confirm. The ACOE does not comment on this guidance or provide any examples where slurry walls have been successfully constructed to the expected depths or lengths that would be required at the Grants site.

- *Incompatibility of groundwater chemistry* – The relatively high concentration of dissolved salts in the groundwater will affect performance of the slurry (bentonite or other clay-type material). Dissolved salts increase the ionic strength of the groundwater and this will cause the bentonite to be more permeable due to alterations in the swelling properties of the clay, as compared to clay behavior in lower ionic strength systems. This further decreases the certainty that a continuous slurry wall can be achieved at the Grants site.

Based on the potential technical difficulties in constructing a slurry wall, the projected construction cost of $14,014,000 in the RSE is likely a gross underestimate. The RSE projection appears to be based on a typical shallow to moderately deep slurry wall installation, and fails to account for the complexity of installation, mobilization and cost associated with specialty equipment needed to reach depths greater than 80 feet. The RSE costs also exclude a remote mixing cost that will be required for a wall of this magnitude, depth, and length, and the remote geographical location of the site. Slurry wall construction to depths greater than 80 feet typically requires the use of a crane with a clamshell attachment; and specialized attachments to construct/key the wall into bedrock. Even with specialized equipment to construct the wall keyed into bedrock, assuring continuity of the key would be extremely difficult and confirmation of a continuous key would not be possible.

Perhaps most importantly, there is no reason to believe that a physical slurry wall would be more effective at preventing groundwater migration than the hydraulic barrier currently in operation. The existing hydraulic barrier has been effective at controlling the plume. There is no benefit to groundwater remediation in replacing the currently functional barrier with one that, given all of the uncertainties and construction challenges, will likely not function properly at all.

The slurry wall alternative is uneconomical, impractical in implementation, and uncertain as to outcome and therefore should be removed from the final RSE report.

Summary

In summary, HMC fundamentally disagrees with the ACOE's conclusions and recommendations for the Grants site, as follows:

- The flushing program is proactive at accelerating the removal of uranium mass from the pile, allowing for its capture and treatment and preventing the long-term drain down of continuously elevated concentrations of uranium over the foreseeable future. Ending this program is not warranted and would be short-sighted in the absence of a better approach because it would prolong the environmental restoration without any means of controlling the source of uranium to groundwater.

- The rebound of uranium into tailings water and subsequent recontamination of the alluvial aquifer is in fact being mitigated by the flushing program. The flushing program is both removing uranium mass and establishing geochemical conditions in the LTP that lead to greater stability with respect to immobilized uranium (*e.g.*, lowered ionic strength, moderate pH, and lowered alkalinity). In addition, the geochemical conditions that have been created by flushing may be enhanced through the addition of amendments to the LTP (e.g., phosphate) that serve to further immobilize uranium and "blind-off" any uranium in lower-permeability materials and prevent back diffusion. A relatively limited number of these locations may exist and are currently being evaluated by HMC.

- The recommendation that a pipeline to slurry tailings to a repository that is 20 miles away be considered is overly simplistic and the incomplete analysis that justifies this serves to weaken the merit of the RSE Report. HMC believes that this option would be far from protective of human health and the environment and is technically infeasible as described.

- The slurry wall is not feasible as described and further evaluation shows that factors such as extreme depth of excavation, inability to create a competent bedrock key, and inability to assure continuity of the slurry wall. Each of these factors taken separately or in combination seriously discounts this as a technology that holds merit at the Grants site.

In closing, HMC continues to find the RSE to be inadequate in its appreciation of the complexity of the Grants site and lacking in its understanding of the conceptual site model and remedial systems. The changes recommended to the systems, and the suggestions for further evaluation, are for the most part inconsistent and speculative.

HMC believes that continued flushing of the LTP remains the best remedial alternative for the Site. Nonetheless, HMC will continue to seek out and implement the most appropriate methods for addressing the unique challenges posed by the Grants LTP and impacted groundwater. To this end, HMC will continue to evaluate the system and, as the RSE suggests, seek opportunities to optimize geochemical conditions to promote precipitation and stabilization of uranium, selenium, and other elements. HMC is committed to the evaluation of these opportunities for further source control in the LTP, as well as on-going evaluation of rebound potential.

We trust that these comments have been helpful and hope that the ACOE will revise to the RSE to appropriately address HMC's concerns.

In the event that the ACOE finalizes the RSE in its current form, we urge EPA, NRC, and NMED to reject any recommendations in the RSE to discontinue flushing of the LTP or give additional consideration to uneconomical, impractical, and potentially ineffective alternatives like slurry pipelines or slurry walls.

In addition, HMC has evaluated the comment response table compiled by the ACOE as an addendum to the revised draft RSE. The following comments were ignored or have not been addressed in the revised document even though the response table indicates that they were addressed:

HMC Comment 25: the ACOE states concurrence with the comment pointing to the inaccuracy of the statement that irrigation water is affecting groundwater through leaching; although the clarification was not made in the revised document.

HMC Comment 27: the ACOE indicates that the CSM figure descriptions will be clarified to better indicate known sources, however this change was not made in the revised document. In addition, requested changes to the CSM were not made. The mill was not removed as a primary source, and the drinking water pathway for groundwater remains complete.

HMC Comment 32: the ACOE indicates that changes will be made to correct the awkward wording relative to groundwater contamination, however this change was not made.

HMC Comment 39: the ACOE "noted" HMC's comment relative to an incorrect citation for a new immobilization technology, however the correction was not made in the revised RSE.

HMC Comment 40: The ACOE indicates that text will be modified to correct the discussion of selenium chemistry, and to correctly indicate that selenium exists as a cation rather than as an anion; this correction was not made in the revised RSE.

References

HMC, 2003. Grants Reclamation Project Background Water Quality Evaluation of the Chinle Aquifers. October 2003.

HMC, 2010. Grants Reclamation Project – Cibola County, NM. Homestake comments on "Focuse Review of Specific Remediation Issues – An Addendum to the Remediation System Evaluation for the Homestake Mining Company (Grants) Superfun Site, New Mexico" – February 2010. Letter from Al Cox, Homestake Mining Company of California to Kathy Yager, U.S. Environmental Protection Agency, May 7, 2010.