Prepared For:

Nuclear Regulatory Commission
11545 Rockville Pike
Rockville, MD 20852

WNI RESPONSE TO NRC REQUEST OF 9/6/01 FOR ADDITIONAL INFORMATION ON SITE CLOSURE PLAN FOR THE SPLIT ROCK, WYOMING SITE

Prepared By:

Shepherd Miller
3801 Automation Way, Suite 100
Fort Collins, Colorado 80525

SHEPHERD MILLER

May 2002

TABLE OF CONTENTS

1.0 INTRODUCTION AND OVERVIEW 1
  1.1 Hydrologic Evaluation 2
  1.2 Site Groundwater Quality 2
  1.3 Geochemical Signature 4
  1.4 Isotope Chemistry 6
  1.5 Radiological Evaluation 8
2.0 RAI GENERAL ACTION ITEMS 13
3.0 RAI HYDROGEOLOGY/MODELING RESPONSES 19
4.0 RAI GEOCHEMICAL RESPONSES 27
5.0 REFERENCES 37

LIST OF TABLES

Table 1-1 Analytical Results of Groundwater, Samples from Drilling, 2002
Table 1-2 Analytical Results from Groundwater, Samples from Wells
Table 1-3 Analytical Results, Aquifer Material Obtained During Drilling in 2002

Table 2-1 Reporting Limits and Analytical Methods for Proposed Monitoring

Table 3-1 Summary of Reported Groundwater Flows
Table 3-2 Comparison of 30-Cell Model and Ogata-Banks Solution

Table 4-1 Analytical Results, Aquifer Material Obtained During Drilling in 2002
Table 4-2 Solid Phase Radiochemistry from Southwest Valley to Red Mule Area Combining Data from SDCP-2002 and SMI-1999
Table 4-3 Contact List for Domestic Well Sampling
Table 4-4 Analytical Results of Groundwater, Samples from Drilling, 2002
Table 4-5 Analytical Results from Groundwater, Samples from Wells

LIST OF FIGURES

Figure 1-1 Predicted Average Uranium Concentration at 100 Years
Figure 1-2 Predicted Average Uranium Concentration in 200 Years
Figure 1-3 Uranium (nat) Aqueous and Solid Along Cross Section G'-G"
Figure 1-4 Aqueous Phase Chloride, Sulfate and Uranium Levels at Select Locations, from Mill Site to Red Mule Area
Figure 1-5 Distribution of δ^{34}S versus Uranium Concentrations in Wells from the WNI Site and the SWV Floodplain
Figure 1-6 Distribution of δ^{34}S versus Sulfate Concentration in Wells from the WNI Site and the SWV Floodplain
Figure 1-7 Solid Phase Ra-226, Th-230, Uranium from Select Locations, Western Nuclear Split Rock Site, Jeffrey City, Wyoming
Figure 1-8 Uranium (nat) Aqueous and Solid Along Cross Section G°-G"
Figure 1-9 Ra-226 and Th-230 Solid Along Cross Section G'-G"
Figure 1-10 Ra-226 and Th-230 Solid Along Cross Section G°-G"

Figure 2-1 Site Investigation Locations 2002 Split Rock Site, Jeffrey City, Wyoming
Figure 2-2 Proposed Surface Water and Groundwater Sampling Locations for Long-term Monitoring

Figure 3-1 Comparison of 30-cell Model and Ogata-Banks Solution

Figure 4-1 Radionuclides in Solid Phase in 2002 Site Investigation Locations, Red Mule Area
Figure 4-2 Ra-226+Th-230/U vs. Ra-226+Th-230 in Solid Phase from Tailings Area, SW Valley and Red Mule Area
Figure 4-3 Aqueous vs. Solid Phase Uranium Concentrations in the Red Mule Area

1.0 INTRODUCTION AND OVERVIEW

Various comments and questions in the NRC's Request for Additional Information (RAI) deal with the general question of observed elevated concentrations of uranium in the groundwater in the Red Mule area. All of these questions can be summarized by the following comment: provide evidence that elevated uranium concentrations in groundwater at the Red Mule area are the result of naturally occurring mineralization and not a result of site-derived constituents. Specifically, this issue is raised in General Comment 1 and Geochemistry Questions 1, 3, 4, 5, 6, 7, 8 and 9. Although these questions are (or have been) addressed independently, the following addresses the overall issue of the observed elevated uranium concentrations at Red Mule.

Some of the individual questions noted above were answered in previous submittals (Shepherd Miller, 2001 and Shepherd Miller, 2002b) and are also addressed in various portions of the Site Closure Plan (SMI, 1999). However, for clarity and completeness, this response includes some previously submitted information as well as new information. The following discussion provides the rationale and supporting investigations and analyses that show it is reasonable to conclude that observed uranium concentrations in groundwater at Red Mule are not site-derived.

When evaluating the elevated uranium concentrations at Red Mule, it is imperative that all of the information be evaluated together. The conclusion that elevated uranium concentrations are the result of naturally occurring mineralization and are not from the tailings impoundment must be drawn from multiple lines of evidence. The multiple lines of evidence that demonstrate elevated uranium concentrations are not site-derived include the following:

1. The hydrological investigation and modeling indicates that the site-specific gradients, hydraulic conductivity and porosities would not permit even conservative constituents to travel from the tailings impoundment to the Red Mule area in the approximately 50 years since the commencement of site operations.
2. A corroborated spatial delineation of the plume indicates that the maximum extent of the site-derived constituents is approximately 1.5 miles west (upgradient) from the Red Mule area. Furthermore, eight wells (four original wells and four newly installed wells) between the leading edge of the plume and the Red Mule area have water quality characteristics demonstrating no impact from site-derived constituents.

3. The geochemical signature of the groundwater at Red Mule differs significantly from the fingerprint of the tailings seepage water. Specifically, groundwater at Red Mule has elevated uranium without the amounts of sulfate and chloride that would be expected if the uranium concentrations were a result of tailings seepage.

4. Evaluation of chemical isotopes from groundwater at Red Mule and groundwater in the tailings plume indicates that the waters at Red Mule are different than the waters in the impacted groundwater plume.

5. Radiological evaluations consisting of geophysical investigations and analytical results of soil samples indicate soils in the Red Mule area have elevated uranium, radium and thorium concentrations. These elevated concentrations are a result of natural conditions, since they can not be attributable to the site. This naturally-occurring mineralized area is the likely source of the elevated uranium observed in the groundwater in the Red Mule area.

Each line of evidence is described in detail below.

1.1 Hydrologic Evaluation

Extensive fate and transport modeling of the current and expected groundwater plume was conducted at the site and documented in the Site Closure Report (SMI, 1999). Subsequent modeling is presented in this report. All of the modeling shows that seepage from the site will not reach the Red Mule area until between 100 and 200 years from now. Using the conservative assumption that uranium behaves as a conservative constituent with no attenuation of concentrations, Figures 1-1 and 1-2 show the expected uranium concentrations 100 and 200 years. If site-specific attenuation parameters are used in the transport model, modeling indicates that uranium will not reach the Red Mule area for approximately 1,000 years (SMI, 2000).

Hydraulic modeling clearly shows that uranium from the tailings seepage would not be expected at Red Mule now, or even in the next 100 years, under conservative assumptions. Therefore, the modeling indicates that the elevated uranium concentrations observed at Red Mule are not associated with tailings seepage.

1.2 Site Groundwater Quality

Groundwater quality measured at the site in 1996-1998, and most recently in 2002, gives a definitive view of the current extent of the eastern portion the tailings-impacted plume from the southwest valley. As discussed in the Site Closure Report (SMI, 1999), uranium and sulfate are good indicator parameters of tailings impacted waters. Groundwater quality data clearly show a plume of impacted water flowing east from the southwest valley. The 1996-1998 data indicate that the leading edge of the plume was approximately 5,000 feet from the mouth of the valley and that wells SWAB-29 and SWEB-14 represented the leading edge of the plume.

Recent groundwater data indicate that the plume has not traveled as far as the 1996 data indicated. Well SWAB-29, which had concentrations of 0.134 mg/L uranium and 203 mg/L sulfate in 1996-1998, now has values of 0.018 mg/L uranium and 112 mg/L sulfate. The 1996-1998 data indicated the water quality was at the limit of background and could potentially have been impacted. Recent data indicates that water quality from well SWAB-29 is at less than background values. While the data are not conclusive as to the exact limit of the plume, the 1996-1998 and 2002 data clearly show that the edge of the plume is somewhere between well SWAB-29 and well SWAB-1. The wells between the edge of the plume and the Red Mule area (SWAB-40, SWAB-31, SWAB-39, SWAB-15, SWAB-28, SWEB-16, SWEB-15, SWEB-13, etc.) clearly have uranium and sulfate concentrations below background limits. These wells represent an area approximately 1-1.5 miles long between the edge of the tailings-impacted waters and the Red Mule area.

To further delineate the extent of the plume and to characterize groundwater between the plume and Red Mule during the 2002 Supplemental Data Collection Program (SDCP), Shepherd Miller installed a series of wells between SWEB-12 and the Red Mule site. These wells help address NRC concerns that a data gap existed with respect to shallow groundwater monitoring in this area. The new monitoring wells installed during this investigation include SWAB-40, SWEB-16, SWEB-15, AND SWAB-39. Specifics of the installation of these wells and well completion logs can be found in the SDCP Trip Report (Shepherd Miller, 2002a).

The concentration of uranium at depth from the mouth of the southwest valley (e.g. SWEB-1) to the Red Mule site (ending at SWAB-33) is shown in Figure 1-3. The data gap the NRC noted with respect to uranium concentrations in the near-surface groundwater was a valid contention, given the upward direction the plume appeared to be taking. However, the new wells installed to monitor shallow groundwater (0 to 100 feet) between the Split Rock site and the Red Mule subdivision demonstrate that there is no connection between the plume that originates from the Split Rock site and the potentially anomalous plume centered around the Red Mule area. In fact, there appears to be a distance of a mile or more between the leading edge of the plume and the point in the Red Mule area at which slightly elevated uranium levels are first detected. Thus, the new data obtained during the 2002 SDCP completely supports the conclusion, reached during the original site characterization studies, that the elevated levels of uranium observed at specific wells in the Red Mule area are not linked to the site-derived contaminant plume.

1.3 Geochemical Signature

Water quality data from wells WN-32C and SWAB-2, which are clearly in the tailings-impacted area, were compared to water quality from wells SWAB-33, which are in the Red Mule area. Uranium, sulfate and chloride were evaluated, since sulfate and chloride are indicator parameters for tailings seepage and uranium is the constituent of concern.

As previously demonstrated in the Site Closure Plan (SMI, 1999), chloride, sulfate and uranium are fairly conservative constituents in the groundwater at the site. Chloride is generally considered conservative in most environments.

Figure 1-4 shows plots of chloride, sulfate, and uranium in the tailings-impacted area in the southwest valley, in the area between the edge of the plum and Red Mule, and in the Red Mule area. These data clearly show that uranium, chloride and sulfate are elevated in the plume. In the area between the plume and Red Mule, all of the constituents are at background levels. The data from Red Mule show chloride and sulfate levels at background levels and elevated uranium values.

It has previously been argued that it is not possible for tailings seepage that contains uranium, sulfate and chloride to migrate to Red Mule with only uranium and not chloride and sulfate. All of the geochemical transport information suggests that chloride would be the most conservative of the three constituents, with sulfate being more conservative than uranium. Given this, chloride would be the first of the three constituents to have reached Red Mule, followed by sulfate and then uranium. There is no geochemical explanation that would reverse that order.

It has been suggested that sulfate could be attenuated by biological processes to form sulfide, and thus attenuate along the flow path. Biological reduction processes, in anoxic environments, are known to lower sulfate concentrations in groundwater as the result of the transformation of sulfate to sulfide and the concomitant precipitation of metal sulfides or loss of gaseous H_2S from the system. However, groundwater chemistry at the Split Rock site indicates that the Split Rock aquifer is generally oxidizing (e.g. low to non-detectable levels of iron and manganese, and detectable nitrate levels) and therefore these reactions will not affect sulfate transport. In addition, current literature indicates that nitrate, manganese, uranium and iron will all be reduced prior to the onset of sulfate reduction. Thus, decreases in sulfate concentration due to biological activity would be accompanied by a decrease in uranium levels as the uranyl ion is reduced to U(IV) and is precipitated as uraninite (UO_2). Sulfate concentrations could also be lowered via the precipitation of gypsum along the flowpath from the Split Rock site to the Red Mule area. However, geochemical speciation modeling using the computer code PHREEQC (Parkhurst and Appelo, 1995) indicates that groundwater at SWAB-1 is undersaturated with respect to common sulfate-bearing mineral phases. It is unlikely that sulfate removal via precipitation reactions significantly affected sulfate concentrations from the edge of the Split Rock site to the Red Mule subdivision.

The oxidized uranyl ion (UO_2^{2+}) forms a large number of stable solution complexes with sulfate, phosphate, fluoride, and carbonate. Above a pH of approximately 5, the uranyl ion forms three different soluble complexes with carbonate: the neutral uranyl carbonate species [$UO_2CO_3^0$], a uranyl dicarbonate ion [$UO_2(CO_3)_2^{2-}$], and a uranyl tricarbonate ion [$UO_2(CO_3)_3^{4-}$]. The uranyl carbonate species are largely responsible for the high degree of uranium mobility commonly observed in oxidizing neutral to high pH groundwaters. However, of the three constituents, uranium is most likely to be affected by geochemical reactions, which would diminish its mobility. Uranium transport can be affected by both geochemical reactions (sorption/desorption and precipitation/dissolution) and biological processes (primarily reduction), which can dramatically alter its mobility in groundwater systems (Colon and others, 2001, Landa, 1995, and Wanty and Nordstrom, 1993). Published values for uranium partition coefficients range from 63 to 630,000 ml/g at pH 7 and 0.4 to 250,000 ml/g at pH of 8 (EPA, 1999). Complexation of uranium by bicarbonate can significantly reduce these sorption reactions. However, in laboratory experiments, sorption of U(VI) onto amorphous and crystalline iron hydroxides accounted for the loss of approximately 28 and 14 percent of the initially present U(VI) in a bicarbonate buffered solution (0.030 mM) containing 1,830 mg/L bicarbonate (Wielinga and others, 2000). Thus, current knowledge suggests that uranium transport will be more subject to geochemical and biological reactions that would retard its transport than either chloride or sulfate. This is likely the reason that there is a greater solution phase depletion of uranium (99 percent) from SWAB-2 to SWAB-29 than for either chloride or sulfate (88 and 92 percent respectively).

Continuing along a hypothetical flow path from the millsite to the Red Mule area, the concentration of chloride, sulfate and uranium increase by 421, 4, and 1,772 percent respectively from SWAB-29 to SWAB-33. From SWAB-2 to SWAB-33 the concentration of sulfate and uranium decrease by 91 and 76 percent respectively. This would suggest that uranium is transported more conservatively than either chloride or sulfate, which contradicts available scientific literature on the geochemistry of these constituents.

Thus, if the uranium, sulfate and chloride seen in the Red mule area were to be associated with the Split Rock site contaminant plume, a mechanism that could account for a greater degree of retardation of sulfate and chloride compared to uranium would need to be applicable in this system. Since the contaminants would follow the same path from the site to any particular well location, mixing, dilution, and other hydrological parameters should be equivalent. Therefore, to suggest that uranium in this system moves more conservatively than either sulfate or chloride goes against currently available scientific understanding of elemental transport.

1.4 Isotope Chemistry

An additional line of evidence that indicates elevated uranium concentrations seen in specific wells in the Red Mule area are not the result of plume migration from the Split Rock site is the stable isotopic signature of $\delta^{34}S$.

In the Site Closure Plan (SMI, 1999) the stable isotopes ^{2}H, ^{18}O, and ^{34}S were used in attempt to delineate site-derived recharge water from background groundwater and groundwater in the Red

Mule area. In its request for additional information, the NRC questioned certain assumptions with respect to the fractionation of hydrogen and oxygen isotopes due to the spray evaporation systems versus the fractionation that would take place from natural evaporative processes. This was a valid observation, and without historical or baseline data to substantiate these assumptions, delineation of plume migration and calculation of travel times become difficult and have not been explored further.

The use of $\delta^{34}S$, on the other hand, is still a valid tracer for determination of contaminant transport. The distinct sulfur isotopic signature associated with the Split Rock site is due to the deposition of isotopically heavier sulfate to the tailings impoundment resulting from the use of sulfuric acid produced from sour gas (SMI, 1999). As previously noted, the stable isotopic composition of sulfur in sulfate is nearly constant in oxidizing, low-temperature environments. Microbial processes are known to fractionate sulfur to a significant degree, but given the oxidizing nature of the Split Rock aquifer, it is unlikely that these processes occurred to any significant extent.

In the original Site Closure Plan (SMI, 1999), an attempt was made to use a mixing model to delineate plume from groundwater in the Red Mule area. The results of this attempt were somewhat ambiguous due to the significant range in $\delta^{34}S$ values, high variability about a statistical regression line in plots of $\delta^{34}S$ versus the inverse of sulfate concentration, and theoretical end members plotted in the middle of the range of $\delta^{34}S$ values. While these factors made the interpretation of mixing trends difficult, a simpler approach to interpreting the $\delta^{34}S$ data suggests that groundwater in the Red Mule area is not impacted by Split Rock site-derived tailings leachate.

Figures 1-5 and 1-6 show the distribution of $\delta^{34}S$ versus the concentration of sulfate and uranium respectively. In assessing the $\delta^{34}S$ data, rather than using a more complex mixing model, we have simplified analyses by looking at populations. Figures 1-5 and 1-6 reveal two distinct populations. Population I contains wells located within the Split Rock site and other wells in the floodplain likely to have been impacted by tailings seepage. This population of wells has an isotopic signature in which all values of $\delta^{34}S$ are greater than –4 per mill. Population II contains background wells and wells located in the Red Mule subdivision. Groundwater from Population II has $\delta^{34}S$ values less than –4 per mill. With the exception of the Johnson well, all $\delta^{34}S$ values measured in the Red Mule area are less than –5.75 per mill and are generally more negative than background wells. It is also important to note that when a border is drawn around these two populations there is essentially no overlap between the two groups. This situation adds to the evidence suggesting wells in the Red Mule area might represent a subset of background conditions and highlight the high degree of variability of uranium levels in the Split Rock alluvial aquifer.

1.5 Radiological Evaluation

During the 2002 SDCP, Shepherd Miller installed a series of wells and boreholes to more clearly define the extent of plume migration and to verify the presence of naturally-occurring uranium bearing minerals in the Red Mule area. Whole rock analysis was done on the solid phase material collected with depth as well as materials collected in the associated aqueous phase, as described in the Supplemental Data Collection Trip Report (Shepherd Miller, 2002a). In addition, wells in the Red Mule area and elsewhere on the site were re-sampled. Results from these investigations are presented in Tables 1-1 through 1-3. It should be noted with respect to the question above, that while somewhat elevated uranium levels were observed at three wells in the Red Mule area, they were all associated with shallow groundwater and no indication of elevated uranium was found below about 70 feet (RM-1).

These results are also presented in Figure 1-3, which shows the concentration of uranium in both the solid and aqueous phase in a cross-section from the Split Rock site to the Red Mule area. This figure illustrates two important points. First, there is a considerable gap, approximately one mile, from well SWAB-17 to well SWEB-15 in which the levels of uranium in groundwater (shallow and deep) is significantly below background levels. Secondly, a comparison of levels of dissolved uranium measured at wells and the solid phase concentration of uranium in the overlying solid phase suggests a strong link between the presence of high-uranium solids with elevated aqueous concentrations. Plotting the dissolved uranium concentration measured at SWAB-40, SWAB-31, SWAB-39, and SWAB-33 against the concentration of uranium measured in the adjacent overlying solid phase (Figure 1-6) demonstrates a significant correlation ($R^2 = 0.84$) between aqueous and solid phase uranium levels.

The RAI points out that the Site Closure Plan (SMI 1999) states that, *"a groundwater plume bearing uranium from the Split Rock site that enters a non-mineralized area might have high uranium concentrations in water and low Th-230 and Ra-226 ratios."* The NRC also points out that examination of Table F-n-1 indicates that wells RM-1 and WM-1 in the Red Mule area fit this description. It should be emphasized that the above statement regarding the concentration of uranium compared to levels of thorium and radium is specific for groundwater entering a "non-mineralized" area. This is a result of the rapid removal of thorium and radium from the contaminant plume via precipitation and/or adsorption reactions within the soil matrix. In contrast, uranium, especially when complexed with carbonate, tends to be considerably more mobile in groundwater that the other two constituents. However, the same statement could be made in an area in which uranium-bearing minerals are present, particularly if groundwater in the area is near neutral and carbonate rich. As the minerals weather, uranium is complexed with bicarbonate and mobilized, yielding groundwater uranium concentrations that are elevated with respect to radium and thorium which are rapidly sorbed or precipitate in near neutral environments. However, the same reasoning is applicable in the statement that the very low values of Th-230 observed at the Johnson well would suggest the presence of naturally-occurring uranium deposits. All current literature indicates that thorium associated with uranium mill tailings rapidly precipitates as tailings solution is leached into the surrounding soils. This is discussed in Geochemistry Question No. 6 and aptly illustrated in Figure 1-7. Thus, the transport of thorium more than a few hundred feet from a tailings impoundment has not been demonstrated and therefore transport of thorium from the millsite to the Red Mule area (a distance of approximately 2 miles) is not supported by current knowledge of thorium geochemistry. In contrast, data collected during the 2002 SDCP supports the presence of natural uranium-bearing minerals in the Red Mule area along with the concomitant elevation in solid phase radium and thorium (Figures 1-3 and 1-8 through 1-10). Again, as discussed in Geochemistry Question No. 6, these radionuclides in soils found at the Red Mule subdivision are also approximately in secular equilibrium, indicating that they are naturally-occurring and have not been transported from the Split Rock facility.

The NRC has also questioned the validity of the radiological data obtained using the KUT (spectral gamma) probe versus that resulting from sediment geochemical analysis. In the Site Closure Plan (SMI, 1999), somewhat higher soil uranium levels were detected at SWAB-33 and SWAB-34 using the KUT probe than were determined by analytical chemistry and therefore the NRC suggested that the potential contribution of K-40 should be addressed.

The KUT logging tool used in these investigations measures the gamma energies of the soil profile as it is lowered down the well. The tool is able to differentiate the various spectral energies at each depth. Uranium, Th-232, and K-40 emit gamma radiation at different energies; K-40 typically emits in the range of 1,370 to 1,570 keV, while U and Th-232 typically emit in the range of 1,660 to 1,860 keV and 2,400 to 2,800 keV respectively. The logging data is then processed, looking at only selected energy ranges attributable to the specific radionuclide of interest. The software used to process the data correlates the amount of energy recorded in a given spectral range to the concentration of the associated radionuclide in the soil. Thus, the KUT probe provides reasonably accurate data on the concentration of uranium in the soil profile.

It should be remembered that the KUT probe is measuring a gamma spectral signal that can be emitted by soil radiological material for some distance and therefore represents an average uranium concentration of the bulk soil. In contrast, a geochemical analysis is typically performed on a 2 gram sub-sample of a homogenized bulk soil sample. The determination of which of the two methodologies gives the most accurate measure of solid phase uranium levels is beyond the scope of this report; however, given the relatively good agreement in values it would seem to be somewhat immaterial for these studies. Importantly, the geophysical logging provides a valuable screening tool, while the geochemical analysis confirmed the presence of uranium and also provides valuable data on ^{226}Ra and ^{230}Th levels, indicating that the uranium present at these sites is naturally-occurring.

Results from the previous Split Rock characterization studies and data from the 2002 SDCP indicate that elevated levels of uranium, radium and thorium are present in soils in the Red Mule area. These data also indicate that the source of these radionuclides is naturally deposited minerals. The RAI questioned WNI's contention that naturally-occurring uranium is present at Red Mule because the concentration of uranium in the processed ore was about 1,800 ppm while levels reported at the Red Mule area were a couple orders of magnitude below this. It should be noted that WNI's contention was not that there is a commercially viable ore body in the Red Mule area, only that naturally occurring, uranium-bearing mineral phases are present in the area. Naturally occurring uranium-bearing minerals are likely to be deposited in the Red Mule area, given the close proximity of a uranium ore source in the mountains to the south. Depositional processes, including transportation and mixing of sediments, along with weathering, will greatly dilute the concentration of uranium-bearing mineral phases as compared to the source rock. It would be expected that the concentration of uranium in the Red Mule area soils is considerably lower than economic ore grade mineral deposits.

In summary, site investigations have shown the presence of sediments in the Red Mule area that contains elevated concentrations of uranium, thorium and radium. The presence of these constituents at nearly equivalent concentrations indicates an environment that has been undisturbed in the recent geologic past in which secular equilibrium between these phases is being approached, and indicates that these mineral phases are naturally-occurring and have not been transported to the Red Mule area from the Split Rock site. In addition, there is a strong correlation between higher uranium concentrations in aquifer material and dissolved uranium in the adjacent groundwater. Also noted is the large region of low concentrations of all site-derived constituents in the groundwater between the plume just outside of the Southwest Valley and the Red Mule area. This information strongly suggests that elevated uranium levels in select wells in the Red Mule area are the result of localized, natural deposition of high concentrations of uranium-bearing minerals, and not the result of transportation from the Split Rock site.

In conclusion, the investigations, analyses and evaluations discussed above clearly indicate that the elevated uranium concentrations observed in groundwater at Red Mule are not site-derived. The evaluations show that hydrologic conditions would not allow constituents from the impoundment to flow to the Red Mule area in the approximately 50 years since operations started. In addition, groundwater quality data indicate that there is a zone of groundwater with low concentrations of uranium and other site-derived constituents approximately 1.5 miles long between the edge of the site plume and the Red Mule area. Further, the chemistry of the groundwater at Red Mule is different than the chemistry of the water in the contaminated plume.

And finally, radiological evaluations indicate that naturally-occurring mineralization consisting of uranium, radium and thorium exists in the Red Mule area soils that is the likely source of the elevated uranium concentrations in groundwater.

While any individual technical evaluation could be criticized, when viewed together the evaluations clearly demonstrate and provide more than a reasonable assurance that the elevated concentrations of uranium in groundwater at Red Mule are not from seepage from the tailings impoundment and the water quality in the Red Mule area represent baseline conditions.

2.0 RAI GENERAL ACTION ITEMS

Item No. 1: *WNI must further characterize the site derived groundwater contamination downgradient of well SWAB-29 and in the vicinity of the Claytor Ranch.*

In spring of 2002 WNI developed and implemented a SDCP to address outstanding NRC issues regarding groundwater conditions at the Split Rock Site. This SDCP was developed with direct input from NRC. The field efforts undertaken are described in the Supplemental Data Collection Trip Report (Trip Report) (SMI, 2002a) accompanying this submittal. This Trip Report presents the methods and scope of the field effort, the drilling logs, the well installation diagrams and the raw data results of soil and water sampling. No significant data analyses are included in the Trip Report. The following responses to the remaining RAI's present analyses of the supplemental data to address the NRC's questions.

A boring was advanced at a location near the Claytor Ranch, downgradient and in line with a topgraphical feature in the granite ridge between the Split Rock Site and the Claytor Ranch (see Figure 2-1). The objective of this boring, BH01, was to confirm that no groundwater from the tailings have impacted the Claytor Ranch area. The location of this boring was determined through discussions with NRC staff. Samples of aquifer materials and ground water were collected during drilling from this boring, these data are reported in Tables 1-1 and 1-3 of the Trip Report (SMI, 2002a) accompanying this submittal. These data were collected from first encounter with groundwater (approximately 55 feet below ground surface) to roughly 95 feet below ground surface. The water quality from this location represents the lower range of background concentrations as evidenced by total dissolved solids concentrations of less than 120 mg/L, SO_4 concentrations of less than 10 mg/L, and U_{nat} concentrations of less than 0.01 mg/L in all samples. Therefore, these data confirm that there are no site impacts at or near the Claytor Ranch from tailings seepage and that the half mile thick granite ridge is an effective barrier to groundwater flow and contaminant transport.

Item No. 2: *Propose a long-term groundwater and surface water monitoring program. The program should start off with a higher frequency immediately after*

> *groundwater pumping ceases with decreased frequency over time. Uranium, sulfate, and chloride should be analyzed in groundwater and surface water, and ammonia should also be analyzed in surface water. Adequate coverage is needed to monitor water quality between the plume and the Jeffrey City water supply wells, near Claytor Ranch wells, Red Mule, and in the Sweetwater River (locations where seepage is highest, downstream, and up-stream background). Adequate long-term surety must be set aside to fund this groundwater monitoring program.*

WNI believes it has demonstrated that the proposed long-term care boundary (LCB), in conjunction with the proposed institutional controls and DOE long-term stewardship, is sufficient to provide the requisite reasonable assurance of protection for public health, safety and the environment. As part of its proposed closure plan, WNI has suggested detection monitoring at a well upgradient of the existing domestic wells in the Red Mule area in order to identify the first arrival of site-derived constituents in advance of potential future impacts to groundwater in the Red Mule area (SMI, 1999, Section 4.3.2.1). WNI does not believe any additional monitoring is warranted or required given the extensive characterization and conservative modeling used to develop the site approach to closure. However, if the DOE should determine that additional monitoring is required during their development of the Long-Term Surveillance Plan (LTSP), then appropriate adjustments to the surety would be made at that time based on the LTSP monitoring program developed by DOE. Further, the activities for which LTSP fund ($250,000 in 1978 dollars) is intended to support contemplates some long-term groundwater/surface water monitoring, implementation of the proposed monitoring program does not necessarily require any adjustment to the standard LTSP fund amount. In addition, recent sampling of groundwater in the mouth of the Southwest Valley (e.g., SWAB-5 and SWAB-3; Table 4-5 of the Trip Report [SM, 2002a]) shows decreases in uranium and sulfate groundwater concentrations at least 25 percent and as much as 58 percent since 1996-1997 (SMI 1999, Appendix F, Table F-5-4). This indicates that concentrations near the valley mouth may be decreasing at rates faster than predicted by the highly conservative groundwater model.

Though WNI believes it has demonstrated that the proposed long-term care boundary (LCB), in conjunction with the proposed institutional controls and DOE long-term stewardship is sufficient to provide the requisite reasonable assurance of protection for public health, safety and the environment, WNI herein presents a long-term groundwater and surface water monitoring plan for the Split Rock site. The objective of this monitoring plan is to provide NRC and the long-term general licensee (DOE) with a means to verify that the requisite reasonable assurance of protection from groundwater transported constituents is maintained. This plan consists of baseline monitoring of both groundwater and surface water upgradient of the site as well as monitoring of the site-derived contaminants in the groundwater and surface water.

Surface Water Monitoring:

Annual surface water monitoring is proposed for the three locations illustrated in the attached Figure 2-2 for the first five years of monitoring. These sampling points represent locations upgradient of any potential site loading, adjacent to the site where maximum site loading is anticipated and downgradient of site loading. After five years, a sampling frequency of once every five years will be sufficient to demonstrate protective conditions are being maintained and model predictions are not exceeded.

Sample testing should be performed by laboratory analysis for the dissolved hazardous constituents uranium and ammonia (NH_4-N), the dissolved indicator parameters sulfate and chloride as well as the field parameters pH and electrical conductance. Table 2-1 summarizes the proposed analytes, reporting limits and analytical methods for each analyte. Sampling should be performed during seasonal low-flow conditions where runoff dilution of groundwater contribution to river water is lowest.

Groundwater Monitoring:

Annual groundwater monitoring is proposed for the locations illustrated in the attached Figure 2-2.

The sampling locations represent monitoring points between the site and Jeffrey City water supply wells (SWAB-30 and SWEB-13), between the site and the Red Mule Area (SWAB-31 and SWEB-16), and the Northwest Valley and the Sweetwater River Floodplain (Well-4R).

SWAB-30 and SWEB-13 represent a deep and shallow well pair directly between the site and Jeffrey City water supply wells that have historically been shown to be un-impacted at all depths. Though flow and transport modeling has shown that townsite pumping at current levels will not draw site derived constituents beyond the LCB at concentrations that are not protective, these monitoring points will allow NRC/DOE to monitor and demonstrate model predictions and protection at this portion of the LCB.

SWAB-31 and SWEB-16 represent a deep and shallow well pair directly between the site and the Red Mule area. These wells currently do not have any site derived impacts and will provide prompt detection of site derived constituents well in advance of transport to the Red Mule area.

Well-4R, located at the toe of the final tailings reclamation cover in the Northwest Valley, will provide monitoring to assure that no changes in the valley source term (i.e., tailings seepage chemistry) will cause unpredicted water quality conditions in the floodplain or river. This monitoring point, in conjunction with the river water quality monitoring discussed above, will ensure that predicted loading conditions, which have been shown to be protective even under minimum low flow river conditions, will remain protective.

Sample testing should be performed by laboratory analysis for the dissolved hazardous constituent uranium (U_{nat}), the dissolved indicator parameters sulfate and chloride as well as the field parameters pH and electrical conductance. Table 2-1 summarizes the proposed analytes, reporting limits and analytical methods for each analyte.

Implementation:

It is proposed that the existing wells SWAB-31 and SWEB-16 would act as effectively as the single well proposed in the October 31, 1999 submittal. As originally proposed these monitoring wells would be sampled on 5 year intervals for:

Indicator Parameters:

- Static Water Level (SWL)
- Field pH
- Field electrical conductance (EC)
- Cations (Na, Ca, K, Mg, Al)
- Anions (Cl, SO_4, $C0_3^{2-}$, $HC0_3^-$)

Constituents of Concern:

- Dissolved uranium
- Combined dissolved radium–226 +228
- Dissolved manganese
- Dissolved molybdenum
- Nitrate (NO_3)
- Ammonia (NH_3)

The downgradient area where site-derived constituents could potentially reach existing drinking water wells has been identified to have existing anomalous natural groundwater concentrations. This makes use of the regional background hazardous constituent values as action levels problematic. For example, existing uranium concentrations in some domestic wells in that area (up to 0.3 mg/L) are naturally above the conservative regional background concentration (0.1 mg/L) developed for the site characterization. Therefore, it is proposed that data from sampling in the early history of the proposed detection well will be used to develop a set of intra-well, location specific background statistics as action levels for implementing the alternate water supply. The proposed action levels would be the well specific background values of the six key constituents of concern (U, Ra-226+228, NO_3, NH_3, Mn, Mo), though only U, NO_3, and Mn are ever anticipated to possibly migrate this distance. Background values would be defined as the upper prediction limit at a 95 percent confidence level for each of these constituents based on the background data set developed from the detection well.

Sufficient data can be collected to develop a statistically significant data set before potential future arrival of site-derived constituents. This is largely due to distant location of the existing site-derived constituents and the slow ground water flow velocities in this area. Sampling and analysis for additional indicator parameters (e.g., SWL, anions, cations,) will provide insight into potential future changes in local or background water quality that may not be related to site-derived constituents, thus preventing false identification of site-derived constituents.

The proposed implementation process would include confirmation of measured site-derived constituent concentrations in the detection wells. Should any site-derived constituents be detected in the monitoring wells above the upper prediction limit, review of the sampling and laboratory QA data would be performed. In addition, review of the other monitoring parameters would be performed to determine if the elevated values are due to site-derived groundwater or due to other non-site related changes in groundwater quality. If no errors in sampling or analysis of the monitoring sample or other non-site related changes to ground water quality are indicated, confirmation sampling would be performed within 90 days of data quality confirmation. If the values of the re-sampling are confirmed to exceed the action levels, the alternate drinking water supply, or another alternative approved by the NRC would be implemented. Due to the low velocity of groundwater flow in this area and the very low action level, it would take over 20 years for the hazardous constituents detected in the monitoring well to reach the existing domestic wells. In addition, it would take many years of actual consumption of hazardous constituents at these concentrations to pose any potential risk to the residents. Therefore, this implementation strategy is conservative and provides an abundance of protection for the existing domestic water users.

3.0 RAI HYDROGEOLOGY/MODELING RESPONSES

Question 25: *The basis for the ground-water flow rates used in the predictive model, as reflected in Table H-c-2, is not clear. These flow rates are less than what would be expected based upon the current flow rate in the two valleys discussed in Section 2.2.5.2. Based upon the flow rates reported in Section 2.2.5.2, the flow out of each valley should be as follows:*

NW Valley

30 gpm	*Assumed long-term seepage from tailings*
55 gpm	*Recharge in the uppermost NW Valley*
25 gpm	*Recharge in the NW Valley below the uppermost valley*
110 gpm	*Flow out of the NW Valley*

SW Valley

32 gpm	*Recharge in the SW Valley below the uppermost valley*

WNI needs to explain this apparent discrepancy.

In general, the approach used by WNI to estimate transient seepage out of the main tailings area is unclear. The source of the recharge rates (Q_{mfi}) presented in Attachment D.f cannot be found. It is not clear how $Q_x(t)$ is being used, and the equation for calculating it may be in error, given that it would indicate that the seepage rate should increase over time as oppose to decrease. The derivation of $Q_x(t)$ and $Q_c(t)$ in Attachment D.f (i.e., tailsqs.xls) is not provided. Appendix E states that for the 1996 stress period, a constant recharge rate of 150 gpm was assumed for the tailings impoundment area in the flow model. This is consistent with the flow rate calculated by using $Q_c(t)$ in Attachment D.f which was apparently derived from the prediction model. Given that the input for the prediction model is taken from the flow model, the approach for determining this seepage rate appears somewhat circular. Because the seepage rate is important in predicting contaminant migration, WNI needs to provide a clear description of how they derived their seepage estimates.

Basis for Valley Flow Rates:

The discrepancies noted in this question are relatively minor and result from two different estimation approaches and the conceptual nature of the values presented in the text. The flow values presented in Section 2.2.5.2 of the main report reflect the rough and rounded flow values developed from the original conceptual model water balance and are presented for descriptive purposes (Table 3-1). Valley recharge estimates based on data presented in Appendix D.c for the aerial recharge on valley floors (approx. 0.55 in/yr) and in Appendix D.b for recharge from the granite outcrops (approx. 6 in/yr). These recharge estimates were then applied to the areas of the various sub-basins of the Northwest and Southwest Valleys (see figure D-b-1 in Appendix D.b of SMI, 1999). Figure E-4-10 from the Site Closure Plan (SMI, 1999) provides greater detail regarding how areas over which recharge was estimated. The table embedded Figure E-4-10 summarizes the recharge for the Upper Valley (tailings basin area), the lower Northwest Valley and the lower Southwest Valley.

The flow values presented in Table H-c-2 represent calculated values from the predictive steady-state (ss30) flow model and were presented to give the reviewer a sense of the current flow from the valleys associated with the projected source concentrations used in transport modeling. These flow values were estimated using the mass balance tool within Groundwater Vistas, which is highly dependent on location of pseudo-section used for flux calculation. The lower value for Northwest Valley seepage (93.5 gpm), as estimated by the mass balance tool within Groundwater Vistas, is roughly 12 percent below the estimated 110 gpm from the combined flows of the conservatively over-estimated steady state tailings seepage (30 gpm), the estimated aerial recharge for the upper valley (55 gpm) and the lower Northwest Valley (25 gpm; 30 gpm + 55 gpm + 25 gpm = 110 gpm). This discrepancy is minor and partially due to the simplification made when describing the general and conceptual valley flow conditions for the reader. In addition, some of the discrepancy is due to small mass balance errors intrinsic to the flow model for the sub-region of the valleys.

The lower value for Southwest Valley seepage (15.8 gpm), as estimated by the mass balance tool within Groundwater Vistas, is roughly half (49 percent) the combed flow resulting from the estimated aerial recharge for the Southwest Valley (32 gpm). This difference is due to local mass balance errors in the model or variations in calculated flow from the mass balance tool in Groundwater Vistas. Though overall model mass balance is good (e.g., 2 percent error), the mass balance in Southwest Valley is higher. The difference between the flow model estimated values and the water balance estimated values is also partly due to the location of the original pseudo-section location used to identify flow from the predictive flow model. No record was retained of the location of pseudo-section used to develop the values presented in Table H-c-2. It should be noted that, for a modeled area of approximately 14,361,000 square feet (330 acres) differences of 13.5 gpm to 16.2 gpm between the numerical model and the conceptual water balance is relatively small and is not considered a significant flaw in the model.

Tailings Seepage Estimates:

The flow model was calibrated to measured head data from the operational historical record and recent measurements. The tailings seepage estimates were developed from a variety of sources, as noted in the original report and in the following text. Primarily, site operational data, the calibrated 3D MODFLOW model and the model TARGET (TAR2DU; ver. 5.0 Dames & Moore, 1995, presented in Appendix D, Attachment g) were used to estimate the seepage from the tailings. Historical operational data were used with other site-specific data in a water balance approach to estimating 1986 seepage rates (Main Report Section 2.1, Appendix D Section D.5, Attachments D.a through D.g; Appendix E, Attachment a).

For other time periods (e.g., 1988, 1993, and 1996) the seepage rates were first estimated using the MODFLOW model as an input parameter, applying fixed seepage rates for those specific time periods. MODFLOW used the recharge package. Pumping stresses were changed for the various time periods (e.g., WDEQ pump back pumping were terminated from 1986 to 1990 when NRC corrective action pumping was initiated, etc.), and applied to the flow model using same tailing hydraulic properties as in 1986 calibration. Tailings seepage was manipulated to achieve a reasonable match in valley heads. These tailings seepage estimates were then checked for reasonableness using a more rigorous 2D unsaturated flow model (Appendix D, attachment g). It should be noted that there were few available operational data, other than measured heads in the valleys, for accurately estimating transitional seepage rates from 1986 to current conditions. All reasonable efforts were made to provide appropriate and representative tailings seepage estimates.

The 1986 tailings seepage estimate for the calibrated model is outlined in the bulleted summary below.

- Calibrated 3D MODFLOW model to 1986 conditions:
  - Discharge from main tailings impoundment based on operational data (Appendix E.a)
    - Combined pumping rates from mill supply well #2 and pumping from the Northwest valley Seepage Pond of 970 gpm
    - WDEQ mandated Corrective Action pumping from Southwest Valley wells WN-A, WN-B, WN-C of 150 gpm to 195 gpm
    - Precipitation contribution to tailings recharge
      - 1986 tailings area of 4.8 x 10^6 ft^2 times the annual precipitation rate of 10.6 in/yr = 60.4 gpm average
    - Evaporative loss from tailings surface
      - 36 in/yr times 1986 tailings pond area of 4.8 x 10^6 ft^2 = 205 gpm
    - Change in the pond storage from 8/7/85 to 8/6/86
      - From 6394.35 ft (8/7/85) to 6394.53 ft (8/6/86) = gain of 0.18 feet
      - 0.18 ft times 1986 tailings area of 4.8 x 10^6 ft^2 = 12.3 gpm (gain in storage)
    - Net: 970 gpm + (150 gpm to 195 gpm) + 60.4 gpm – 205 gpm – 12.3 gpm = 963 gpm to 1,008 gpm (expected 1986 tailings seepage rate)
  - July/August head targets in 85 wells (Table E-4-2, E-4-3)

The 1996 tailings seepage estimate of 150 gpm for the calibrated model is outlined in the bulleted summary below.

- 3D MODFLOW model to 1996 conditions:
  - July/August head targets in 84 wells (Table E-4-2, E-4-4)
  - Tailings partially drained, no standing water remaining on surface
  - Area for tailings recharge based WN-33 well cluster water level data, estimated using best professional judgment, coincides approximately with pre-milling 6,330 contour (see Plate B-d-12 in Appendix B.d), recharge set at 150 gpm (Sec. E.4.4.2.), area estimated to be 1,240,000 sq. ft. or 28.5 acres (Figure E-4-10). 150 gpm over 1.24 x106 sq ft is approx. 0.023 ft/day (Q/A=Ki)
  - Tailings K = 2.5 ft/day (1996 Figure E-4-17A), therefore 1996 gradient (i) 0.023 ft/day/2.5 ft/day = 0.009 ft/ft
  - Check on reasonableness of estimate, review of local gradients
    - based on 1996 contours in Figure E-4-16 gradient from center of tailings (estimated water level in tailings of 6,330 ft) to 6315 contour down NW Valley (15 ft head change over 1,600 ft ≈ 0.009 ft/ft)
  - Used MODFLOW recharge package, provided best target head match, using same tailing hydraulic properties as in 1986 calibration.
  - Checked with TARGET2D

The Target 2D model handled the unsaturated component of flow through the tailings and subsurface with more rigor than the 3D flow model. The Target 2D was used to support the estimate of tailings seepage analysis presented in Appendix D, Attachment f. Specifically, the values for Q_{mfi} presented in Appendix D, Attachment f were developed from the calibrated 3D MODFLOW model follows:

- 1000.7 gpm was selected from the range of estimated values presented in Appendix E, Attachment a, where 1986 tailings seepage was estimated to range from 963.1 gpm to 1008.1 gpm. These values were developed using a mss water balance approach using historical operational data. Operational data such as mill discharge rates, Well 2 (mill water supply well) pumping rates, Northwest Valley seepage pond pump back rates, estimates of pond area/evaporation and precipitation rates, etc. were used to provide an estimate of tailings impoundment water balance for the 1986 time period (Main Report Section 2.1, Appendix D Section D.5, Attachments D.a through D.g).
- The 639.2 gpm tailings recharge (seepage) value for the period 1988, the 293-gpm tailings recharge (seepage) value for the period 1993 and the 150-gpm tailings recharge (seepage) value from 1996 period were estimated using the flow model and check against the Target 2D model results for rough agreement.

These tailings seepage/recharge values were required to establish reasonable residual head values in the upper valley target wells (see Appendix E, Section 4.6.3.3). We believe that the calibration to measured head values using hydraulic conductivity values based on numerous site specific hydrologic tests and the available operational site data provide the best available estimate of site area groundwater flow conditions. In addition, the calibration of the transport model, based on the flow vectors from the MODFLOW modeling, reasonably represents measure constituent distributions. Therefore, though the tailings seepage estimates and valley seepage estimates addressed in this RAI are not likely exact, they are based on a large amount of site specific data and analysis.

Question 26: *The equation presented in Attachment J.c for the Ogata-Banks analytical solution appears to be incorrect. The analytical solution should be…Please verify that the correct equation was used to evaluate dispersion. Also, to verify that the one-dimensional spreadsheet model provides an acceptable representation of dispersion in the ground-water system. The input values (i.e., C_{in}, X, and V) used in the analytical equation should be provided.*

The equation in the original November 13, 1999 report had a misprint, however the correct equation was evaluated in the comparison with 30-cell mass balance model presented in Supplement H.c.1.

The Ogata Banks equation expressed in terms of $C(x,t)/C_i$ should read:

$$\frac{C}{C_i} = 1 - \left(1 - \frac{C_b}{C_i}\right) 0.5 \times \left[\operatorname{erfc}\left[\frac{x - vt/R}{2\sqrt{\alpha vt/R}}\right] + \exp\left[\frac{x}{\alpha}\right] \operatorname{erfc}\left[\frac{x + vt/R}{2\sqrt{\alpha vt/R}}\right]\right]$$

Where:

$C_i = 3.0$ mg/L, initial concentration
$C_b = 0.7$ mg/L, background concentration
$x = 3240$ ft, distance
$v = 270$ ft/yr, groundwater velocity
$\alpha = 40$ ft, dispersivity
$R = 16.66$, retardation coefficient

Note: The Ogata Banks solution was derived for the specific initial/boundary conditions of $C(x,0)=0$, $C(0,t)=C_0$, $C(\infty,t)=0$. These conditions describe a system where a plume with a source concentration C_0 is migrating through a system with initial concentration of $C=0$. For this application, water with concentration $C=0$ is "flushing out" a system that has an initial concentration of $C=C_i$. Therefore, the solution has been modified for the initial/boundary conditions of $C(x,0)=C_i$, $C(0,t)=0$, $C(\infty,t)=C_i$. The above solution also includes a term to account for the background concentration in the system.

Question 27: *The representation of the mass balance model used as part of the one-dimensional spreadsheet model may be in error. As presented in the report (i.e., on page H-c-14), the mass balance model has incompatible units. To have consistent units, it would appear that source and sink terms would need to be multiplied by the time over which flow occurs. Please verify that the correct equation was used in the analysis. In addition, to allow a check of WNI's verification of the model, please include input and results from the verification analysis.*

It is assumed that the mass balance equation addressed in the question refers to page H-c-1-4 and not the referenced H-c-14.

The correct equation and consistent units were used for the analysis. The 30-cell model incorporates a pore volume approach, where time is a dimensionless parameter. The Q (volumetric flow rate of water) term refers to the flow through the cell (L^3/t) over the time necessary for one pore volume to pass through the cell (t_{PV}).

$$Q = L^3/t \times t_{PV}$$

Q is expressed in units of volume, and is equal to the pore volume of one model segment. In this context, the units presented in the mass balance equation are compatible.

The mass balance equation can be equivalently expressed by the following.

$$M_n^{t} = M_n^{t-1} + C_{n-1}^{t-1} \times PV + C_n^{t-1} \times PV$$

Where:

PV = pore volume of one model segment (L^3)
M = mass of solute (m)
C = concentration of solute (m/L^3)
n = model cell (dimensionless)
t = model timestep (dimensionless)

The 30-cell model results have been compared against the Ogata Banks solution to the one-dimensional advection-dispersion equation. The formulation and input parameters for the Ogata Banks solution are presented in the response to Question 26. The comparison is presented in Table 3-2 and Figure 3-1. The dissolved concentrations calculated with the 30-cell model are in very good agreement with the results of the Ogata Banks solution.

4.0 RAI GEOCHEMICAL RESPONSES

Question 6: *Provide justification that uranium concentrations in groundwater, thought to be naturally occurring, are higher than predicted for background water quality.*

The NRC notes that the upper UPL for uranium in the original submittal was 0.126 mg/L and that two wells in the Red Mule area (RM-1 and SWAB-33) have uranium concentrations that exceed this value. It is further stated that, "*For uranium to be naturally occurring, the background levels generally would be representative of the upper values. Either the background value is too low and not representative of higher concentrations in the groundwater where naturally-occurring uranium deposits exist or the Red Mule area contains WNI site-derived tailings solutions mixed with natural groundwater.*"

This statement is generally true and points out the difficulty in accurately defining background concentrations. Often background wells are picked very conservatively because it is difficult prior to an investigation to predict how far a plume may have migrated. As a result, many wells that might not be affected are not included on a precautionary basis. This is the case for the Red Mule area. Because it is downgradient from the WNI site, wells in this area were not included for background calculations in the Site Closure Plan (SMI, 1999). However, hydrogeological and geochemical studies indicate that site-impacted groundwater has not reached the Red Mule area at this point in time. If this is true, and Red Mule wells are not affected, then they would and should be included in calculations estimating background water quality. In addition, in the Site Closure Plan (SMI, 1999), Shepherd Miller used a very rigorous statistical approach for determination of background. If Shepherd Miller had instead used the replicate t-test method, as described by EPA in Appendix B of OSWER-9950.1, which is the RCRA Ground-Water Monitoring Technical Enforcement Document, the upper critical values for U and SO_4 using the EPA method, at $\alpha = 0.01$, are 0.153 mg/L and 117.4 mg/L respectively.

These values are higher than the calculated values, using the same data set that Shepherd Miller developed (November, 13, 2001) using the statistical approach provided in the Site Closure Plan (SMI, 1999). This serves to highlight the conservatism employed by WNI and the difficulty in establishing a background value that provides reasonable assurance of minimizing false positive as well as false negative detections.

"Additional evidence is needed to support the proposed naturally occurring uranium deposits would create elevated concentrations in groundwater at Red Mule."

In January of 2002 Shepherd Miller initiated a SDCP designed, in part, to obtain geochemical evidence that would support the contention that naturally occurring uranium-bearing minerals contribute to the elevated uranium levels observed at certain wells in the Red Mule area. Sample collection and analytical methodology used during these investigations are detailed in SDCP Trip Report (Shepherd Miller, 2002a). Data collected during the studies confirm the presence of elevated uranium ($U_{(nat)}$), radium-226, and thorium-230 in surface soils (0 to 35 ft bgs) in the Red Mule area (Table 4-1; Figure 4-1). Elevated levels of these constituents in surface soils were previously identified and the data were presented in Table F-6-4 from the Site Closure Plan (SMI, 1999).

The concentration of uranium in the top 35 feet of solids in the Red Mule area ranges from 0.47 to 12.7 mg/kg with an average value of 2.47 mg/kg. Below this depth the levels range from 0.29 to 1.93 mg/kg with and average value of 0.82 mg/kg (Table 4-1). It should be noted that from the previous investigation a background level of 0.865 mg/kg was calculated for uranium in aquifer solids (Table F-6-5; SMI, 1999) and that most of the values observed in the deeper aquifer material during this study are at or below this background level. The values given in Table 4-2 include data from the current round of sampling as well as data from Table F-6-4 from the original report.

During the 2002 SDCP levels of radium-226 and thorium-230 in sediments and aquifer solids were also determined; these data are presented in Table 4-2 and in Figure 4-1. Scientific literature strongly suggests that radium and thorium associated with uranium mill tailings are rapidly depleted from the groundwater via sorption and/or precipitation reactions and therefore rarely migrate away from the tailing to any appreciable extent (Langmuir, 1980 and Landa, 1995). Therefore, the presence of solids that contain elevated levels of radium, thorium and uranium a considerable distance from a mill tailings site would indicate that the solids contained a naturally occurring mineral phase that was high in these constituents. Analysis of the data collected during the 2002 sampling (Table 4-1) along with data previously reported in the Site Closure Plan (Table 4-2) suggest that this is the case in the Red Mule area. Further more, plotting the concentration of Ra-226 + Th-230 divided by $U_{(nat)}$ against the concentration of Ra-226/Th-230 (Figure 4-2a and 4-2b) illustrates that Ra, Th, and U in this system behaves like that observed at other tailings sites, and indicates that the elevated levels in the Red Mule area are natural in origin. Samples taken in close proximity to the Split Rock site are significantly depleted in radium and uranium when compared to thorium as would be predicted from other published studies of radionuclide geochemistry (Landa, 1995, and Wanty and Nordstrom, 1993). Moving away from the Split Rock site down the Southwest Valley, there is a reversal and thorium is now depleted with respect to radium and uranium, again as predicted by previous research. In contrast, at the Red Mule area radium-226, thorium-230, and uranium are near secular equilibrium as would be expected in an area with naturally occurring mineral phases. Figure 1-7 illustrates these phenomena sequentially, moving from the Split Rock site (well WN-33D) to the Red Mule area (SWAB-33). From Figure 1-7, it is evident that most of the uranium and almost all of the radium and thorium is removed from the tailings leachate prior to well SWEB-1. The levels of solid phase radium and thorium remain at essentially background levels from SWEB-1 to the Red Mule subdivision, at which point there is a dramatic increase in these constituents in the local soils. It should again be pointed out that these constituents are near secular equilibrium in the Red Mule area, in considerable contrast to their relative proportions at plume affected locations. Thus, careful analysis of previous data, along with that collected during the 2002 SDCP, indicates that naturally occurring uranium-bearing mineral phase are present in the Red Mule area. In addition, these mineral phases appear to be concentrated in the top 30 to 40 feet of the dune sands in this area.

Inspection of the fence diagrams (Figure 1-3 and 1-8 through 1-10) further indicates that elevated levels of uranium in the groundwater are closely associated with these concentrated mineral phases. Elevated levels of uranium are found in the groundwater in wells SWAB-39 and SWAB-33 (0.105 mg/L and 0.337 mg/L respectively) associated with high concentrations of radium, thorium and uranium in the upper unconsolidated sediments. In contrast, wells that are west of the Red Mule area (SWAB-40 and SWEB-16) contain background levels of uranium in both the aquifer material and in the groundwater.

Careful analysis of past and recently collected data also shows a high degree of local variability with respect to the uranium concentration in the aquifer material and in groundwater. This local variability is consistent with the nature of the depositional environment of the area. Alluvial deposits, whether by streamflow or sheetflow (braided-stream) deposition, are characterized by a high degree of grain-size and/or density stratification, which is related to the proximity and strength of the fast moving water. Eolian deposits are typically characterized by sorting based on mineral density, with heavier minerals tending to be concentrated in the troughs of dunes. Owing to contrasting densities between different minerals, uranium-bearing minerals can be preferentially sorted from other minerals and deposited locally in relatively high concentrations.

Mineralogical analysis of solid phase samples to identify the radionuclide bearing mineral phases was initially planned for the in the SDCP. However, currently available mineral identification technologies such as XRD typically require that the target mineral is present in concentrations much higher than those observed in the dune sand material, and therefore we did not attempt to identify the mineral phases. Regardless, the geochemical evidence from site studies indicates that the subsurface dune sands in the Red Mule area do contain naturally-occurring mineral phases that are high in uranium, radium and thorium, and that the presence of these minerals could account for the sporadically elevated uranium levels of uranium observed in select groundwater wells.

Question 7: *Provide site characterization data at multiple depths and locations in the Red Mule area.*

In the RAIs it was noted that a data gap existed for groundwater in the upper 150 feet of the Split Rock aquifer between well SWEB-12 ant the Red Mule site. It was further noted that as the contaminant plume migrates east from the Split Rock site, it appears to be rising upwards toward the water table surface.

During the 2002 SDCP, Shepherd Miller installed a series of wells between SWEB-12 and the Red Mule site to address these concerns of the NRC. The new monitoring wells installed during this investigation include SWAB-40, SWEB-16, SWEB-15, and SWAB-39. The installation of these wells and well completion logs can be found in the SDCP Trip Report (Attachment B of Shepherd Miller, 2002a).

The concentration of uranium with depth from the mouth of the southwest valley (e.g. SWEB-1) to the Red Mule site (ending at SWAB-33) is shown in Figure 1-3. The gap in data, noted by the NRC, with respect to uranium concentration in the near surface groundwater was a valid contention given the upward direction the plume appeared to be taking. However, the new wells installed to monitor shallow groundwater (0 to 100 feet) between the Split Rock site and the Red Mule subdivision indicate that there is no connection between the plume that originates at the Split Rock site and the potentially anomalous plume centered around the Red Mule area. In fact, there appears to be a distance of approximately one mile between the leading edge of the plume and the point in the Red Mule area at which slightly elevated uranium levels are first detected. Thus, the new data obtained during the 2002 SDCP completely supports the conclusions reached during the original site characterization studies. Specifically, that the elevated levels of uranium observed at specific wells in the Red Mule area are not linked to the site derived contaminant plume and represent the influence of naturally occurring materials on local groundwater quality.

Question 8: *Re-evaluate the opportunity to sample additional wells in the Red Mule area.*

WNI has expended considerable time and effort to identify all the current properties and owners in the Red Mule area and to identify wells that exist on these properties. In addition, WNI has attempted to contact the owners and/or residents of Red Mule properties to acquire permission to access and sample known wells. Many of the owners could not be contacted and/or permission to sample could not be acquired. The wells for which access could be acquired were sampled and the data presented to the NRC and to the residents/owners of the wells. As part of the Supplemental Data Collection Program, WNI continued to attempt to gain access to known wells in the Red Mule area for sampling and water quality characterization. Table 4-3 presents a summary of the private well contact efforts made for the 2002 SDCP.

Question 9: *Geochemical evidence must be provided to demonstrate that the low uranium mineral contents found in sediments above the water table correlate to the concentrations of dissolved uranium found in (shallow and deep) groundwater at Red Mule. Additional information is needed to explain the potential influence of K-40 on the KUT borehole log results and the comparison of the log data to the sediment data should result in similar values for uranium.*

During the 2002 SDCP, Shepherd Miller installed a series of wells and boreholes in order to more clearly define the extent of plume migration and verify the presence of naturally-occurring uranium-bearing minerals in the Red Mule area. Whole rock analysis was done on the solid phase material collected with depth as well as the associated aqueous phase, as described in the SDCP Trip Report (SMI, 2002a). In addition, wells in the Red Mule area and elsewhere on the site were re-sampled. Results from these investigations are presented in Tables 4-1, 4-4 and 4-5. It should be noted with respect to the question above, that while somewhat elevated uranium levels were observed at three wells in the Red Mule area, they were all associated with shallow groundwater and no indication of elevated uranium below about 70 feet (RM-1) was found.

These results are also presented in Figure 1-3, which shows the concentration of uranium in both the solid and aqueous phase in a cross-section from the Split Rock site to the Red

Mule area. This figure illustrates two important points. First, there is a considerable gap, approximately one mile, from well SWAB-17 to well SWEB-15 in which the levels of uranium in groundwater (shallow and deep) is well below background levels. Secondly, a comparison of levels of dissolved uranium measured at wells and the solid phase concentration of uranium in the overlying solid phase suggests a strong link between the presence of high-uranium solids with elevated aqueous concentrations. Plotting the dissolved uranium concentration measured at SWAB-40, SWAB-31, SWAB-39, and SWAB-33 against the concentration of uranium measured in the adjacent overlying solid phase (Figure 4-3) demonstrates a significant correlation ($R^2 = 0.84$) between aqueous and solid phase uranium levels.

The RAI points out that the Site Closure Plan (SMI 1999) states that, *"a groundwater plume bearing uranium from the Split Rock site that enters a non-mineralized area might have high uranium concentrations in water and low Th-230 and Ra-226 ratios".* The NRC also points out that examination of Table F-n-1 indicates that wells RM-1 and WM-1 in the Red Mule area fits this description. It should be emphasized that the above statement regarding the concentration of uranium compared to levels of thorium and radium is specific for groundwater entering a "non-mineralized" area. This is a result of the rapid removal of thorium and radium from the contaminant plume via precipitation and/or adsorption reactions within the soil matrix. In contrast, uranium, especially when complexed with carbonate, tends to be considerably more mobile in groundwater that the other two constituents (Landa, 1995). However, the same statement could be made in an area in which uranium-bearing minerals are present, particularly if groundwater in the area is near neutral and carbonate rich. As the minerals weather, uranium is complexed with bicarbonate and mobilized yielding groundwater uranium concentrations that are elevated with respect to radium and thorium which are rapidly sorbed or precipitate in near neutral environments. However, the same reasoning is applicable in the statement that the very low values of Th-230 observed at the Johnson well would suggest the presence of naturally occurring uranium deposits. All current literature indicated that thorium associated with uranium mill tailings rapidly precipitates as tailings solution is leached into the surrounding soils. This has been discussed above in Geochemistry

Question No. 6 and aptly illustrated in Figure 1-7. Thus, the transport of thorium more than a few hundred feet from a tailings impoundment has not been demonstrated and therefore transport of thorium from the millsite to the Red Mule area (a distance of approximately 2 miles) is not supported by current knowledge of thorium geochemistry. In contrast, data collected during the 2002 SDCP supports the presence of natural uranium bearing minerals in the Red Mule area along with the concomitant elevation in solid phase radium and thorium (Figures 1-9, 1-10, and 4-1). Again, as discussed in Geochemistry Question No. 6 above, these radionuclides in soils found at the Red Mule subdivision are also approximately in secular equilibrium, indicating that they are naturally occurring and not transported from the Split Rock facility.

The NRC has also questioned the validity of the radiological data obtained using the KUT probe versus that resulting from sediment geochemical analysis. In the Site Closure Plan somewhat higher soil uranium levels were detected at SWAB-33 and SWAB-34 using the KUT probe that than were determined by analytical chemistry and therefore the NRC suggested that the potential contribution of K-40 should be addressed.

The company that performed the geophysical logging (COLOG, Golden, Colorado) indicates that the KUT (spectral gamma) logging tool used in these investigations measures the gamma energies of the soil profile as it is lowered down the well and the tool is able to differentiate the various spectral energies at each depth. Uranium, Th-232, and K-40 emit gamma radiation at different energies; K-40 typically emits in the range of 1,370 to 1,570 keV, while U and Th-232 typically emit in the range of 1,660 to 1,860 keV and 2400 to 2,800 keV respectively. The logging data is then processed looking at only selected energy ranges attributable to the specific radionuclide of interest. The software used to process the data correlates the amount of energy recorded in a given spectral range to the concentration of the associated radionuclide in the soil. Thus, in theory, the KUT probe provides relatively accurate data on the concentration of uranium in the soil profile.

It should be remembered that the KUT probe is measuring a gamma spectral signal that can be emitted by soil radiological material for some distance and therefore represents and average uranium concentration of the bulk soil. In contrast, a geochemical analysis is typically performed on a 2-gram sub-sample of a homogenized bulk soil sample. Which methodology gives the most accurate measure of solid phase uranium levels is beyond the scope of this report. However, given the relatively good agreement in values it would seem to be somewhat immaterial for these studies. Importantly, the geophysical logging provides a valuable screening tool, while the geochemical analysis confirmed the presence of uranium and also provides valuable data on ^{226}Ra and ^{230}Th levels, indicating that the uranium present at these sites is naturally occurring.

Results from the previous Split Rock characterization studies as well as data from the 2002 SDCP indicate that elevated levels of uranium, radium and thorium are present in soils in the Red Mule area. These data also indicate that the source of these radionuclides is naturally deposited minerals. The RAI questioned WNI's contention that naturally occurring uranium is present at Red Mule because the concentration of uranium in the processed ore was about 1,800 ppm while levels reported at the Red Mule area were a couple orders of magnitude below this. It should be noted that WNI's contention was not that there is a commercially viable ore body in the Red Mule area, only that naturally occurring, uranium-bearing mineral phases are present in the area. Naturally occurring uranium-bearing minerals are likely to be deposited in the Red Mule area, given the close proximity of a uranium ore source in the mountains to the south. Depositional processes, including transportation and mixing of sediments, along with weathering, will greatly dilute the concentration of uranium-bearing mineral phases as compared to the source rock. Thus, it would be expected that the concentration of uranium in the Red Mule area soils is considerably lower than ore grade mineral deposits.

In summary, past and recent investigations have shown the presence of elevated concentrations of uranium, thorium and radium sediments in the Red Mule area. The presence of these constituents at nearly equivalent concentrations indicates an environment that has been relatively undisturbed in the recent geologic past, in which secular equilibrium between these phases is being approached, and indicates that these mineral phases are naturally occurring and have not been transported to the Red Mule area from the Split Rock site. In addition, there is a strong correlation between higher uranium concentrations in aquifer material and dissolved uranium in the adjacent groundwater. Also noted is the large region of low uranium concentration in the groundwater between plume just outside of the Southwest Valley and the Red Mule area. This information demonstrates that elevated uranium levels in select wells in the Red Mule area are the result of localized, natural deposition of high concentrations of uranium-bearing minerals, and not the result of transportation from the Split Rock site. Further, measured decreases in groundwater concentrations at the mouth of the Southwest Valley indicates that concentrations near the valley mouth may be decreasing at rates faster than predicted by the highly conservative groundwater model and that the Red Mule area may never be impacted by site derived constituents.

5.0 REFERENCES

Colon, C.F.J., Brady, P.V., Siegel, M.D. and Lindgren, E.R., 2001. "Historical Case Analysis of Uranium Plume Attenuation." NUREG/CR-6705; SAND2000-2554, U.S. Nuclear Regulatory Commission, Washington, DC.

Landa, E.R., 1995. "Geochemical and Biogeochemical Controls on Element Mobility in and around Uranium Mill Tailings." In: L.H. Filipek and G.S. Plumlee (Editors), The Environmental Geochemistry of Mineral Deposits, Part B: Case Studies and Research Topics. Reviews in Economic Geology. Society of Economic Geologists, Inc., Chelsea, MI, pp. 527-538.

Langmuir, D. and J. Herman, 1980. "The Mobility of Thorium in Natural Waters at Low Temperatures." *Geochimica et Cosmochimica Acta.* Vol. 44, pp. 1753-1766.

Parkhurst, D.L. and Appelo, C.A., 1995. User's Guide to PHREEQC (Version 2): A Computer Program for Speciation, Batch_Reactions, One-Dimensional Transport and Inverse Geochemical Calculations. 99-4259, U.S. Geological Survey, Denver, CO.

Shepherd Miller, 2002a. "Supplemental Data Collection Trip Report." Consultant's Report. May.

Shepherd Miller, 2002b. "WNI Response to NRC Request of 9/6/01 for Additional Information on Site Closure Plan for the Split Rock, Wyoming Site." January.

Shepherd Miller, 2001. "WNI Response to NRC Request of 9/6/01 for Additional Information on Site Closure Plan for the Split Rock, Wyoming Site." November.

Shepherd Miller, Inc. (SMI), 2000. "Supplement to October 29, 1999 Split Rock Site Closure Report." Consultant's Report. January 14.

Shepherd Miller, Inc. (SMI), 1999. "Site Closure Plan." Consultant's Report. October

U.S. Environmental Protection Agency (EPA), 1999. "Understanding Variation In Partition Coefficient, Kd, Values. Volume II: Review of geochemistry and available Kd values for cadmium, cesium, chromium, lead, plutonium, radon, strontium, thorium, tritium (3H), and uranium." EPA402-R-99-004B, U.S. Environmental Protection Agency, Washington, DC.

Wanty, R.B. and Nordstrom, D.K., 1993. "Natural Radionuclides." In: W.M. Allen (Editor), Regional Groundwater Quality. Van Nostrand Reinhold, New York, N.Y.

Wielinga, B., Bostick, B., Hansel, C.M., Rosenzweig, R.F. and Fendorf, S., 2000. "Inhibition of Bacterially Promoted Uranium Reduction: Ferric (hydr)oxides as Competitive Electron Acceptors." *Environ. Sci. Technol.*, 34(11): 2190-2195.

TABLES

Table 1-1 Analytical Results of Groundwater, Samples from Drilling, 2002 (Page 1 of 6)

Location	Sample depth, ft.	Date Sampled	Alkalinity as CaCO3 (mg/L)	Ammonia as N (mg/L)	Nitrate+Nitrite as N (mg/L)	TOC (mg/L)	TDS, Calculated (mg/L)	TDS @ 180 (mg/L)	A/C Balance (± 5) %	Al (mg/L)	Anions (meq/L)
SMI BH01	55	1/13/02	87	<0.05	1.8		117.18	284	-1.47	<0.1	2.17
	65	1/13/02	82	<0.05	1.66		109.90	192	-1.05	<0.1	2.03
	75	1/13/02	71	<0.05	1.21		87.53	191	0.01	<0.1	1.62
	85	1/13/02	72	<0.05	1.06		93.57	168	0.81	<0.1	1.71
	95	1/13/02	75	<0.05	1.15		96.56	150	0.38	<0.1	1.78
SMI BH02	36	1/13/02	164	<0.05	0.96	3.45	255.97	303	0.54	<0.1	4.59
	56	1/13/02	156	<0.05	1.16	3.17	227.97	378	0.51	<0.1	4.15
	65	1/13/02	154	<0.05	1.1	1.24	227.53	273	1.31	0.3	4.12
	75	1/13/02	158	<0.05	1.12	0.76	232.20	273	-0.36	<0.1	4.27
	85	1/14/02	147	<0.05	1.14	1.13	218.62	253	1.24	<0.1	3.96
	95	1/14/02	156	<0.05	1.07	1.47	231.52	283	2.64	<0.1	4.14
	105	1/14/02	159	<0.05	0.97	2.33	240.82	330	1.70	<0.1	4.34
	115	1/14/02	152	<0.05	1.08	1.36	223.90	279	1.42	<0.1	4.04
	105	1/14/02	156	<0.05	0.95	2.55	243.16	279	1.48	<0.1	4.37
SMI BH03	36	1/15/02	130	0.17	1.48	3.24	234.44	265	0.01	<0.1	4.14
	55	1/16/02	140			2.91		273			
	75	1/16/02	130	<0.05	1.63	1.68	207.18	226	-0.51	<0.1	3.72
	85	1/16/02	139	<0.05	1.45	0.94	208.23	225	0.38	<0.1	3.77
	95	1/16/02	140	<0.05	1.55	0.80	210.80	261	0.22	<0.1	3.83
	105	1/16/02	147	<0.05	0.99	0.71	224.79	268	1.11	<0.1	4.07
	115	1/16/02	149	0.16	0.59	0.50	216.74	248	0.50	<0.1	3.96
SMI BH04	55	1/16/02	162	<0.05	1.26	2.43		299		<0.1	
	65	1/16/02	158	<0.05	1.34	1.14		241		<0.1	
	75	1/16/02	152	<0.05	1.29	0.54		245		<0.1	
	85	1/16/02	147	<0.05	1.2	0.58		249		<0.1	
	95	1/16/02	148	<0.05	1.05	0.56		241		<0.1	
	105	1/16/02	149	<0.05	0.9	0.52		251		<0.1	
	115	1/16/02	152	<0.05	0.59	<.5		261		<0.1	

Table 1-1 Analytical Results of Groundwater, Samples from Drilling, 2002 (Page 2 of 6)

Location	Sample depth, ft.	Date Sampled	Alkalinity as CaCO3 (mg/L)	Ammonia as N (mg/L)	Nitrate+Nitrite as N (mg/L)	TOC (mg/L)	TDS, Calculated (mg/L)	TDS @ 180 (mg/L)	A/C Balance (± 5) %	Al (mg/L)	Anions (meq/L)
SMI BH05	55	1/17/02	160			3.92		272		<0.1	
	75	1/17/02	154	<0.05	1.14	2.97		217		<0.1	
	85	1/17/02	150	<0.05	1.06	0.95		255		<0.1	
	95	1/17/02	148	<0.05	1.09	0.67		273		<0.1	
	105	1/17/02	142	<0.05	0.95	<.5		248		<0.1	
	115	1/17/02	147	<0.05	0.94	0.74		246		<0.1	
	105	1/17/02	144	<0.05	0.91	<.5		249		<0.1	
SWAB40	36	1/12/02	134	0.08	1.03	9.16	206.27	239	0.20	<0.1	3.74
	45	1/12/02	142	<0.05	0.69	1.80	217.77	240	2.21	<0.1	3.88
SWEB15	80	1/8/02	137	0.07	0.55	9.36		270		<0.1	
	95	1/8/02	146	0.08	0.49	2.92		244		<0.1	
	105	1/8/02	149	<0.05	0.44	2.12		238		<0.1	
	115	1/8/02	152	<0.05	0.44	0.83		239		<0.1	
SWEB16	40	1/10/02	103	<0.05	1.66	8.74		224		<0.1	
	60	1/10/02	132	0.06	1.66	7.76		222		<0.1	
	80	1/10/02	137	0.11	1.78	11.60		289		<0.1	
	90	1/10/02	143	0.1	0.89	3.85		233		<0.1	
	100	1/10/02	144	<0.05	1.28	1.90		237		<0.1	
	110	1/10/02	154	<0.05	1.08	1.14		241		<0.1	
	118	1/10/02	151	<0.05	0.94	1.00		262		<0.1	
	40	1/10/02	104	0.08	1.67	9.05		208		<0.1	
	55	1/10/02								<0.1	

Table 1-1 Analytical Results of Groundwater, Samples from Drilling, 2002 (Page 3 of 6)

Location	Sample depth, ft.	Date Sampled	As mg/L	Ba mg/L	Ca mg/L	Cations meq/L	Cl mg/L	Fe mg/L	Mg mg/L	Mn mg/L	Mo mg/L	P mg/L
SMI BH01	55	1/13/02	0.001	<0.1	26.7	2.10	4.80	<0.03	3.4	0.01	<0.1	<0.1
	65	1/13/02	0.002	<0.1	25.4	1.99	4.56	<0.03	3.3	0.01	<0.1	<0.1
	75	1/13/02	0.003	<0.1	21.1	1.62	<1	<0.03	2.8	<0.01	<0.1	<0.1
	85	1/13/02	<0.001	<0.1	23.7	1.74	<1	<0.03	2.9	<0.01	<0.1	<0.1
	95	1/13/02	0.002	<0.1	24.9	1.79	<1	<0.03	3.1	<0.01	<0.1	<0.1
SMI BH02	36	1/13/02	0.001	<0.1	43.7	4.64	6.80	<0.03	8.3	0.04	<0.1	<0.1
	56	1/13/02	0.001	<0.1	46.6	4.19	4.24	<0.03	8.5	0.04	<0.1	<0.1
	65	1/13/02	0.002	<0.1	46.9	4.23	4.99	<0.03	8.5	0.03	<0.1	<0.1
	75	1/13/02	0.004	<0.1	47.9	4.24	8.61	<0.03	8.9	0.03	<0.1	<0.1
	85	1/14/02	<0.001	<0.1	45.1	4.06	5.34	<0.03	8.9	0.04	<0.1	<0.1
	95	1/14/02	0.003	<0.1	46.4	4.37	4.64	<0.03	8.7	0.03	<0.1	<0.1
	105	1/14/02	0.005	<0.1	48.0	4.49	8.17	<0.03	8.9	0.03	<0.1	<0.1
	115	1/14/02	0.004	<0.1	48.3	4.16	5.58	0.08	7.3	<0.01	<0.1	<0.1
	105	1/14/02	0.005	<0.1	48.2	4.50	9.55	<0.03	9.0	0.03	<0.1	1.2
SMI BH03	36	1/15/02	<0.001	<0.1	38.6		19.90	<0.03	4.6	0.04	<0.1	<0.1
	55	1/16/02										
	75	1/16/02	0.001	<0.1	36.5		10.80	<0.03	5.3	0.04	<0.1	<0.1
	85	1/16/02	0.001	<0.1	40.9		8.90	<0.03	6.4	0.01	<0.1	<0.1
	95	1/16/02	0.003	<0.1	43.8		9.70	<0.03	7.2	0.01	<0.1	<0.1
	105	1/16/02	0.002	<0.1	50.2		9.90	<0.03	7.7	<0.01	<0.1	<0.1
	115	1/16/02	0.004	<0.1	49.7		7.66	<0.03	6.7	<0.01	<0.1	<0.1
SMI BH04	55	1/16/02	0.001	<0.1	50.1		12.00	<0.03	8.7	0.03	<0.1	<0.1
	65	1/16/02	0.002	<0.1	45.6		12.40	<0.03	8.1	0.04	<0.1	<0.1
	75	1/16/02	0.003	<0.1	47.2		9.92	<0.03	7.9	0.03	<0.1	<0.1
	85	1/16/02	0.004	<0.1	47.9		8.71	<0.03	6.9	<0.01	<0.1	<0.1
	95	1/16/02	0.004	<0.1	48.1		9.72	<0.03	7.0	<0.01	<0.1	<0.1
	105	1/16/02	0.003	<0.1	48.1		10.30	<0.03	7.0	0.01	<0.1	<0.1
	115	1/16/02	0.001	<0.1	50.7		7.87	<0.03	6.9	<0.01	<0.1	<0.1

Table 1-1 Analytical Results of Groundwater, Samples from Drilling, 2002 (Page 4 of 6)

Location	Sample depth, ft.	Date Sampled	As mg/L	Ba mg/L	Ca mg/L	Cations meq/L	Cl mg/L	Fe mg/L	Mg mg/L	Mn mg/L	Mo mg/L	P mg/L
SMI BH05	55	1/17/02	<0.001	<0.1	49.4		10.60	<0.03	8.8	0.05	<0.1	<0.1
	75	1/17/02	<0.001	<0.1	48.0		9.63	<0.03	8.5	0.04	<0.1	0.1
	85	1/17/02	0.001	<0.1	49.0		11.00	<0.03	8.5	0.04	<0.1	<0.1
	95	1/17/02	0.002	<0.1	47.2		8.25	<0.03	8.3	0.05	<0.1	0.1
	105	1/17/02	0.003	<0.1	45.3		6.74	<0.03	8.0	<0.01	<0.1	<0.1
	115	1/17/02	0.001	<0.1	47.8		9.13	<0.03	8.0	<0.01	<0.1	<0.1
	105	1/17/02	0.003	<0.1	45.4		9.00	<0.03	8.0	<0.01	<0.1	<0.1
SWAB40	36	1/12/02	<0.001	<0.1	42.4	3.76	9.00	<0.03	6.3	0.06	<0.1	<0.1
	45	1/12/02	0.003	<0.1	47.8	4.06	4.48	<0.03	6.7	0.02	<0.1	<0.1
SWEB15	80	1/8/02	<0.001	<0.1	46.8		6.77	<0.03	6.8	0.07	<0.1	<0.1
	95	1/8/02	0.001	<0.1						<0.01	<0.1	
	105	1/8/02	0.003	<0.1	46.4		7.46	<0.03	6.6	<0.01	<0.1	0.1
	115	1/8/02	0.004	<0.1	48.3		5.66	<0.03	6.9	<0.01	<0.1	<0.1
SWEB16	40	1/10/02	<0.001	<0.1	37.7		12.70	<0.03	5.1	0.07	<0.1	0.2
	60	1/10/02	<0.001	<0.1	42.2		9.13	<0.03	5.5	0.06	<0.1	<0.1
	80	1/10/02	<0.001	<0.1	45.8		9.25	<0.03	6.7	0.10	<0.1	<0.1
	90	1/10/02	0.003	<0.1	46.9		7.94	<0.03	6.1	0.01	<0.1	0.2
	100	1/10/02	<0.001	<0.1	47.2		9.93	<0.03	6.4	0.11	<0.1	0.1
	110	1/10/02	0.003	<0.1	47.4		7.62	<0.03	6.1	0.01	<0.1	<0.1
	118	1/10/02	0.004	<0.1	49.7		5.98	<0.03	6.3	<0.01	<0.1	0.2
	40	1/10/02	<0.001	<0.1	37.6		12.50	<0.03	5.1	0.07	<0.1	0.2
	55	1/10/02	<0.001	<0.1	<1		<1	<0.03	<1	<0.01	<0.1	<0.1

Table 1-1 Analytical Results of Groundwater, Samples from Drilling, 2002 (Page 5 of 6)

Location	Sample depth, ft.	Date Sampled	K mg/L	Ra-226 pCi/g	Na mg/L	SO4 mg/L	TDS Balance dec. %	Th-230 pCi/g	U_{nat} mg/L
SMI BH01	55	1/13/02	4.69	<0.2	8.32	8.09	2.42	<0.2	0.008
	65	1/13/02	4.87	<0.2	7.38	7.02	1.74	<0.2	0.005
	75	1/13/02	3.86	<0.2	5.44	5.13	2.18	<0.2	0.003
	85	1/13/02	4.33	<0.2	4.58	8.40	1.79	<0.2	0.002
	95	1/13/02	3.68	<0.2	4.44	9.45	1.55	<0.2	0.003
SMI BH02	36	1/13/02	4.25	<0.2	38.00	50.50	1.18	<0.2	0.090
	56	1/13/02	4.98	<0.2	23.40	39.80	1.65	<0.2	0.049
	65	1/13/02	5.15	<0.2	23.10	39.60	1.20	<0.2	0.054
	75	1/13/02	4.78	<0.2	22.50	38.00	1.17	<0.2	0.065
	85	1/14/02	4.23	<0.2	22.10	38.20	1.15	<0.2	0.036
	95	1/14/02	4.54	<0.2	27.70	39.50	1.22	<0.2	0.067
	105	1/14/02	4.48	<0.2	28.30	41.50	1.36	<0.2	0.083
	115	1/14/02	4.52	<0.2	23.40	37.10	1.24	<0.2	0.058
	105	1/14/02	4.44	<0.2	28.30	44.20	1.14	<0.2	0.080
SMI BH03	36	1/15/02	2.78	<0.2	40.10	42.20	1.13	<0.2	0.056
	55	1/16/02							
	75	1/16/02	3.50	<0.2	30.50	33.90	1.09	<0.2	0.062
	85	1/16/02	4.16	<0.2	25.70	30.90	1.07	<0.2	0.023
	95	1/16/02	4.71	<0.2	21.70	31.40	1.23	<0.2	0.044
	105	1/16/02	4.26	<0.2	20.80	37.80	1.19	<0.2	0.022
	115	1/16/02	4.59	<0.2	19.60	34.80	1.14	<0.2	0.024
SMI BH04	55	1/16/02	4.24	0.3	35.40	53.90		<0.2	0.150
	65	1/16/02	4.35	<0.2	31.00	41.20		<0.2	0.109
	75	1/16/02	4.48	<0.2	22.80	34.50		<0.2	0.051
	85	1/16/02	4.66	<0.2	20.30	33.40		<0.2	0.023
	95	1/16/02	4.70	<0.2	20.00	34.00		<0.2	0.024
	105	1/16/02	4.73	<0.2	20.30	36.00		<0.2	0.022
	115	1/16/02	4.80	0.3	20.10	36.00		<0.2	0.013

Table 1-1 Analytical Results of Groundwater, Samples from Drilling, 2002 (Page 6 of 6)

Location	Sample depth, ft.	Date Sampled	K mg/L	Ra-226 pCi/g	Na mg/L	SO4 mg/L	TDS Balance dec. %	Th-230 pCi/g	U_{nat} mg/L
SMI BH05	55	1/17/02	4.47	<0.2	30.50	51.30		<0.2	0.049
	75	1/17/02	4.45	<0.2	25.10	43.60		<0.2	0.030
	85	1/17/02	4.79	<0.2	24.50	45.50		<0.2	0.033
	95	1/17/02	4.72	<0.2	22.50	36.20		<0.2	0.038
	105	1/17/02	4.60	<0.2	20.60	33.70		<0.2	0.025
	115	1/17/02	4.54	<0.2	21.00	38.00		<0.2	0.018
	105	1/17/02	4.59	<0.2	20.60	33.90		<0.2	0.025
SWAB40	36	1/12/02	3.07	<0.2	23.40	35.40	1.15	<0.2	0.033
	45	1/12/02	3.64	<0.2	23.30	41.90	1.10	<0.2	0.043
SWEB15	80	1/8/02	3.45	<0.2	24.40	49.60		<0.2	0.014
	95	1/8/02		<0.2				<0.2	0.011
	105	1/8/02	3.19	<0.2	22.00	39.60		<0.2	0.015
	115	1/8/02	3.30	<0.2	22.10	42.20		<0.2	0.018
SWEB16	40	1/10/02	1.71	<0.2	19.60	36.80		<0.2	0.013
	60	1/10/02	2.61	<0.2	19.30	33.60		<0.2	0.015
	80	1/10/02	3.19	<0.2	21.60	50.60		<0.2	0.013
	90	1/10/02	2.96	<0.2	21.40	42.90		<0.2	0.032
	100	1/10/02	3.11	<0.2	21.90	39.80		<0.2	0.029
	110	1/10/02	2.88	<0.2	21.00	44.00		<0.2	0.031
	118	1/10/02	2.98	<0.2	21.20	45.50		<0.2	0.033
	40	1/10/02	1.70	<0.2	19.50	36.00		<0.2	0.014
	55	1/10/02	<1	<0.2	<1	<1		<0.2	<0.0003

Table 1-2 Analytical Results from Groundwater, Samples from Wells (Page 1 of 4)

Location	Date Sampled	Depth, ft	Easting	Northing	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	TOC mg/L	TDS mg/L	HCO3 mg/L	Ca mg/L
Cline	06-Feb-02		19056.27	972.59	<0.5	1.50	0.529	234	165	50.7
Cox-1	12-Feb-02	89.8	17990.6	2012.1	<0.5	1.24			160	35.08
Cox-2	12-Feb-02		18223.6	1273.8	<0.5	1.12		252	190	36.5
Fox-1	06-Feb-02	40	19377.36	959.19	<0.5	0.88	<0.5	226	170	47.5
Johnson	12-Feb-02	65	15351.59	-21.893	<0.5	2.87		208	151	31.9
KK-1	06-Feb-02	57	17048.46	955.22	<0.5	3.16	1.145	293	185	59.5
RM-1	06-Feb-02	60	15808.7	1179.6	<0.5	3.95	2.046	396	257	81.0
Stoilkov Home	06-Feb-02		16184.67	-283.28	<0.5	1.30	0.541	243	173	51.7
SWAB-1	07-Feb-02	28	7401.5	2654.5	<0.5	84.50			289	337
SWAB-10	04-Feb-02	29.9	7556.836	1493.015	<0.5	1.69			200	
SWAB-14	04-Feb-02	18.1	2945.734	3580.138	<0.5	0.23	0.678	356	178	74.9
SWAB-15	05-Feb-02	22.5	9074.378	1413.004	<0.5	0.72			309	
SWAB-17	07-Feb-02	38.5	8206.33	2370.382	<0.5	4.93			172	82
SWAB-2	05-Feb-02	28.3	6684.8	3582.8	96.7	113.00			332	
SWAB-26	04-Feb-02	25	350.6	5571.7	<0.5	1.70	1.145	260	160	46.7
SWAB-28	07-Feb-02	33.5	11009.9	1281.8	<0.5	1.26			200	53.1
SWAB-29	07-Feb-02	18.5	11999.3	1730.3	<0.5	<0.1			221	61.6
SWAB-30	05-Feb-02	23.5	4591.905	3679.661	<0.5	0.77	1.017	287	181	61.2
SWAB-31	06-Feb-02	40	13847.02	1306.919	<0.5	1.13	0.693	234	190	56.2
SWAB-32	06-Feb-02	34	13783.04	-64.251	<0.5	1.15	1.722	324	213	66.0
SWAB-33	06-Feb-02	29	17782.78	2417.2	<0.5	0.36	5.354	501	281	72.4
SWAB-34	06-Feb-02	33	15564.22	2943.62	<0.5	0.85	1.158	255	192	58.8
SWAB-35	04-Feb-02	20	3930.41	4845.79	<0.5	0.58	0.514	302	184	66.5
SWAB-39	06-Mar-02	44.1	14661.99	1225.46	<0.5	1.48			197	55.2
SWAB-4	04-Feb-02	18.8	4674.3	6651.4	10.0	40.20	3.789	1330	258	241.0
SWAB-5	04-Feb-02	20.4	5079.4	5762.4	5.2	14.90	1.652	679	201	113.0
SWAB-6	04-Feb-02	22.92	4911.4	2208.2	<0.5	1.12			193	

Table 1-2 Analytical Results from Groundwater, Samples from Wells (Page 2 of 4)

Location	Date Sampled	Depth, ft	Easting	Northing	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	TOC mg/L	TDS mg/L	HCO3 mg/L	Ca mg/L
SWAB-7	07-Feb-02	20.3	9963.6	2100.8	<0.5	4.88			197	71.7
SWEB-10	04-Feb-02	231	5102.1	5783.5	<0.5	1.45	<0.5	435	177	92.4
SWEB-12	07-Feb-02	494	9952.2	2078.1	<0.5	0.43			182	51.9
SWEB-13	05-Feb-02	555	4598.663	3705.72	<0.5	<0.1	<0.5	272	39.7	22.7
SWEB-14	11-Feb-02	109.5	11974.4	1743.5	<0.5	<0.1			201	54.4
SWEB-15	06-Mar-02	99.59	14662.06	1251.2	<0.5	0.52			188	52.4
SWEB-16	06-Mar-02	99.75	13840.21	1329.51	<0.5	0.90			178	52.8
SWEB-6	05-Feb-02	396	6706.2	3611.3	0.8	<0.1			100	
SWEB-8	11-Feb-02	195	7417.342	2676.008	<0.5	0.38			178	66.6
SWEB-9	11-Feb-02	416	8167.5	2389.8	<0.5	<0.1			60.2	3.2
Veach-2	06-Feb-02	75	15750	1600	<0.5	3.65	1.381	312	218	63.8
WM-1	06-Feb-02	65	16081	1980.83	<0.5	1.91	1.124	289	215	64.7
WM-2	06-Feb-02	65	16099	1687	<0.5	2.09	0.956	302	217	62.4
SWAB-15 (2)	15-Apr-02	27.5	9074.37	1413.004		1.01		380		
SWAB-37	15-Apr-02		21897.83	4857.53		0.4		249		
SWAB-38	15-Apr-02		27439.16	9957.64		0.39		271		
SWAB-3	24-Apr-02		5743.8	4291	0.1	9.79	2.0662	864		136

Table 1-2 Analytical Results from Groundwater, Samples from Wells (Page 3 of 4)

Location	Date Sampled	Depth, ft	CO3 mg/L	Cl Mg/L	Mg mg/L	Mn mg/L	K Mg/L	Ra-226 Pci/L	Ra-228 pCi/L	Na mg/L	SO4 mg/L	U_{nat} mg/L
Cline	06-Feb-02		<1	2.63	6.50	<0.01	4.04	<0.2	<1	21.7	38.8	0.040
Cox-1	12-Feb-02	89.8	<1	6.6	5.7	<0.01	4.7	<0.2		30.3	32.1	0.031
Cox-2	12-Feb-02		<1	2.45	5.94	<0.01	4.04	<0.2		18.0	39.0	0.053
Fox-1	06-Feb-02	40	<1	4.66	7.05	<0.01	5.10	0.5		20.7	33.0	0.027
Johnson	12-Feb-02	65	<1	6.48	4.62	<0.01	3.23	<0.2		15.3	24.8	<0.0003
KK-1	06-Feb-02	57	<1	10.70	9.07	<0.01	5.16	<0.2		28.6	49.1	0.073
RM-1	06-Feb-02	60	<1	17.20	12.40	<0.01	5.21	<0.2		39.0	62.2	0.314
Stoilkov Home	06-Feb-02		<1	5.85	7.21	<0.01	4.50	<0.2	<1	21.8	37.8	0.027
SWAB-1	07-Feb-02	28	<1	35.3	85.6	<0.01	8.4	<0.2		92.2	773.0	1.240
SWAB-10	04-Feb-02	29.9	<1	10.4		<0.01		<0.2	2		41.5	0.056
SWAB-14	04-Feb-02	18.1	<1	29.60	9.57	<0.01	5.73	<0.2	<1	29.9	83.6	0.045
SWAB-15	05-Feb-02	22.5	<1	26.7		<0.01		<0.2	<1		70.5	0.106
SWAB-17	07-Feb-02	38.5	<1	11.9	13.1	0.0139	6	0.3		37.7	43.4	0.104
SWAB-2	05-Feb-02	28.3	<1	47.2		6.45		3.6	6		1320.0	1.390
SWAB-26	04-Feb-02	25	<1	19.40	5.67	<0.01	6.51	<0.2	<1	27.7	28.2	0.016
SWAB-28	07-Feb-02	33.5	<1	7.6	7.4	<0.01	4.2	0.5		22.5	27.1	0.049
SWAB-29	07-Feb-02	18.5	<1	5.7	12	<0.01	3.5	<0.2		6.4	112.0	0.018
SWAB-30	05-Feb-02	23.5	<1	8.65	8.02	0.0212	5.61	<0.2	<1	24.1	55.4	0.032
SWAB-31	06-Feb-02	40	<1	10.10	6.45	<0.01	3.19	<0.2	<1	23.6	29.5	0.033
SWAB-32	06-Feb-02	34	<1	13.50	8.86	<0.01	5.32	<0.2	<1	34.1	56.9	0.163
SWAB-33	06-Feb-02	29	<1	29.70	12.80	<0.01	6.46	<0.2	<1	81.4	117.0	0.337
SWAB-34	06-Feb-02	33	<1	7.89	8.03	<0.01	3.60	<0.2	<1	24.6	39.7	0.054
SWAB-35	04-Feb-02	20	<1	10.60	8.15	<0.01	6.32	<0.2	<1	21.9	60.5	0.032
SWAB-39	06-Mar-02	44.1	<1	11	9.7	0.0134	3.3	<0.2	<1	24.4	35.4	0.105
SWAB-4	04-Feb-02	18.8	<1	36.30	55.30	<0.01	19.60	2.8	4	58.5	521.0	1.140
SWAB-5	04-Feb-02	20.4	<1	31.50	30.40	0.831	12.80	0.5	1.5	42.5	224.0	0.434
SWAB-6	04-Feb-02	22.92	<1	18		<0.01			<1		66.3	0.045
SWAB-7	07-Feb-02	20.3	<1	4	6.6	<0.01	4.1	0.3		12.3	34.6	0.082

Table 1-2 Analytical Results from Groundwater, Samples from Wells (Page 4 of 4)

Location	Date Sampled	Depth, ft	CO3 mg/L	Cl Mg/L	Mg mg/L	Mn mg/L	K mg/L	Ra-226 pCi/L	Ra-228 pCi/L	Na mg/L	SO4 mg/L	U_{nat} mg/L
SWEB-10	04-Feb-02	231	<1	25.60	13.50	0.143	7.58	<0.2	2.1	25.2	129.0	0.042
SWEB-12	07-Feb-02	494	<1	18.60	8.00	<0.01	7.10	<0.2		32.5	55.2	0.025
SWEB-13	05-Feb-02	555	<1	96.00	5.80	0.0296	7.73	<0.2	<1	64.2	47.2	<0.0003
SWEB-14	11-Feb-02	109.5	<1	6.50	8.20	0.207	5.90	<0.2		24.5	45.7	0.017
SWEB-15	06-Mar-02	99.59	<1	4.80	7.20	<0.01	3.70	<0.2	<1	23.6	42.0	0.022
SWEB-16	06-Mar-02	99.75	<1	6.40	6.60	<0.01	3.50	<0.2	<1	23.8	44.5	0.035
SWEB-6	05-Feb-02	396	1.7	16.20		0.0733		<0.2	<1		<1	0.001
SWEB-8	11-Feb-02	195	<1	34.20	9.70	<0.01	6.70	<0.2		27.0	61.4	0.018
SWEB-9	11-Feb-02	416	4.1	10.50	6.10	<0.01	6.40	0.4		20.7	16.0	<0.0003
Veach-2	06-Feb-02	75	<1	11.60	9.59	<0.01	4.26	<0.2	<1	34.1	43.8	0.170
WM-1	06-Feb-02	65	<1	9.54	9.18	<0.01	4.71	<0.2	<1	28.8	44.2	0.165
WM-2	06-Feb-02	65	<1	9.58	9.01	<0.01	4.62	<0.2		30.7	44.0	0.155
SWAB-15	15-Apr-02			22.6							64.5	.0868
SWAB-37	15-Apr-02			7.29							47.5	0.103
SWAB-38	15-Apr-02			7.39							55.7	0.0415
SWAB-3	24-Apr-02		229	16.4	33.6	0.01	13.5			65.9	339	0.492

Additional Constituents Tested

Location	Date Sampled	Al (mg/L)	As (mg/L)	Ba (mg/L)	Fe (mg/L)	P (mg/L)
SWAB-3	24-Apr-02	<0.1	0.0233	<0.1	0.03	<0.1

Table 1-3 Analytical Results, Aquifer Material Obtained During Drilling in 2002 (Page 1 of 3)

	Depth	Ra-226 pCi/g	Th-230 pCi/g	Uranium mg/kg
SMI BH01	15	0.4	0.32	0.631
	25	0.6	0.46	0.894
	30	0.5	0.3	0.941
	50	0.4	0.25	0.82
	55	0.4	0.22	0.772
SMI BH02	10	2.3	2.2	4.98
	15	2.6	2.6	6.98
	20	0.4	0.28	1.01
	30	0.2	0.12	0.506
	40	0.4	0.26	0.912
	50	0.5	0.3	0.894
	60	0.4	0.33	0.868
	70	0.3	0.21	0.704
	80	0.4	0.32	0.728
	85	0.38	0.27	0.714
	90	0.2	0.25	0.847
	95	0.2	0.13	0.361
	105	0.2	<0.1	0.434
	115	<0.1	<0.1	0.293
SMI BH03	5	0.92	0.67	1.18
	10	-	-	2.46
	15	0.89	0.84	1.54
	20	-	-	1.28
	25	0.47	0.25	1.02
	35	0.45	0.24	1.1
	40	0.47	0.26	1.17
	50	0.52	0.35	1.36
	55	0.55	0.36	1.42
	65	0.45	0.42	1.64
	75	0.53	0.32	1.49
	85	0.31	0.21	0.524
	95	0.16	0.11	0.327
	105	0.13	<0.1	0.326
	115	0.17	<0.1	0.293
SMI BH04	5	1.1	1.1	1.45
	10	-	-	0.78
	15	0.5	0.42	1.8
	25	0.6	0.43	1.93
	35	0.4	0.19	1.34
	45	0.4	0.37	1.39
	55	0.6	0.22	1.31
	60	-	-	1.93

Table 1-3 Analytical Results, Aquifer Material Obtained During Drilling in 2002 (Page 2 of 3)

	Depth	Ra-226 pCi/g	Th-230 pCi/g	Uranium mg/kg
SMI BH04	65	0.6	0.47	1.93
	70	-	-	0.92
	75	0.3	0.27	0.932
	85	0.3	0.35	0.73
	95	0.4	0.34	1.23
	105	0.2	0.12	0.306
	115	<0.1	0.16	0.363
SMI BH05	5	0.6	0.48	0.612
	10	0.6	0.48	0.67
	15	0.6	0.47	0.836
	20	0.4	0.36	1.67
	25	0.3	0.2	1.09
	35	0.3	0.43	1.13
	45	0.5	0.33	1.25
	55	0.4	0.34	1.05
	60	0.5	0.3	0.933
	65	0.4	0.27	0.919
	75	0.5	0.31	0.94
	85	0.3	0.31	0.972
	95	0.2	0.17	0.693
	105	0.2	0.16	0.602
	115	0.2	0.11	0.288
SWAB-40	5	0.4	0.26	0.463
	15	0.5	0.32	0.55
	25	0.5	0.42	1.59
	35	0.4	0.24	1.08
	45	0.3	0.16	0.658
SWEB-15	5	0.8	0.57	0.914
	15	0.7	0.46	1.42
	20	-	-	3.93
	25	2	0.74	3.58
	30	-	-	2.26
	35	0.7	<0.1	1.36
	45	0.46	0.33	1.1
	55	0.3	0.22	0.683
	65	0.2	0.12	0.447
	75	0.3	<0.1	0.349
	85	0.4	0.18	0.592
	90	0.5	0.33	0.81
	95	0.3	0.21	0.339
	105	0.2	0.13	0.32

Table 1-3 Analytical Results, Aquifer Material Obtained During Drilling in 2002 (Page 3 of 3)

	Depth	Ra-226 pCi/g	Th-230 pCi/g	Uranium mg/kg
SWEB-16	5	1.1	0.71	1.22
	15	0.5	0.28	0.66
	25	0.7	0.41	1.21
	35	0.6	0.44	1.1
	40	0.5	0.27	0.87
	45	0.4	0.25	0.64
	55	0.4	0.18	0.48
	60	0.4	0.18	0.56
	75	0.2	<0.1	0.54
	80	0.4	0.34	0.93
	85	0.3	0.27	0.85
	100	0.3	0.11	0.4
	110	<0.1	<0.1	0.3
	118	0.2	0.13	0.36

Table 2-1 Reporting Limits and Analytical Methods for Proposed Monitoring

Analyte[a]	Required Reporting Limit[b] (mg/L or specified units)	Method[c]
Aluminum	0.10	EPA 6010
Ammonia	0.05	EPA 350.1
Bicarbonate	0.10	EPA 310.1
Calcium	0.05	EPA 200.7/6010
Carbonate	0.10	EPA 310.1
Chloride	0.7	EPA 200.7/6010/325.3
Potassium	0.10	EPA 200.7/6010
Magnesium	0.01	EPA 200.7/6010
Manganese	0.01	EPA 200.7/6010
Molybdenum	0.05	EPA 200.7/6010
Nitrate + Nitrite as N	0.10	EPA 353.2
Radium-226	0.2 pCi/L	EPA 903.0
Radium-228	1.0 pCi/L	EPA 904.0
Sodium	0.05	EPA 200.7/6010
Sulfate	1.0	EPA 200.7/6010/375.4
Static Water Level	± 0.01 ft	Manual
Field Electrical Conductance	1.0 µS/cm	EPA 120.1
Field pH	+ 0.1 std. unit	EPA 150.1
Uranium (total, fluorimetric)	0.001	EPA 908.1

Notes:

[a] Dissolved, all samples filtered to 0.45 mm

[b] Reporting limits are determined based on low-level samples. The reporting limits for other samples may be higher due to dilution or sample matrix effects. Note that some reporting limits changed over the course of the project.

[c] Methods used for specific sampling events or experimental studies may be specified in a Statement of Work or an experimental protocol.

[d] ELI = Energy Laboratories, Inc.

[e] AF:GH = Atomic Fluorescence (Gaseous Hydride)

Table 3-1 Summary of Reported Groundwater Flows

CURRENT CONDITIONS (Section 2.2.5.2 of the main text)			
Upper Valley			
Tailings Seepage 1996:	150gpm		
Upper Valley Recharge:	55 gpm		
Upper Valley Total:	205 gpm		
Northwest Valley		**Southwest Valley**	
NW Valley Flow:	185 gpm	SW Valley Flow	20 gpm (10% of upper valley flow)
NW Valley Recharge:	25 gpm	SW Valley Recharge:	32 gpm
Total Flow out NW Valley:	210 gpm	Total Flow out SW Valley:	52 gpm
LONG-TERM CONDITIONS (Section 2.2.5.2 of the main text & Table H-c-2)			
Long-term Tailing Seepage: (ss30)	30 gpm		
Upper Valley Recharge:	55 gpm		
Upper Valley Total:	85 gpm		
Northwest Valley		**Southwest Valley**	
NW Valley Flow:	85 gpm	SW Valley Flow	0 gpm (0% of upper valley flow)
NW Valley Recharge:	25 gpm	SW Valley Recharge:	32 gpm
Section 2.2.5.2 of the main text Total Flow out NW Valley:	110 gpm	Section 2.2.5.2 of the main text Total Flow out SW Valley:	32 gpm
Table H-c-2 Values:	93.5 gpm		15.8 gpm
Difference:	**13.5 gpm** (12%)		**16.2 gpm** (51%)

Table 3-2 Comparison of 30-Cell Model and Ogata-Banks Solution

Time (years)	30-Cell Model (C/C_I)	Ogata-Banks (C/C_I)
0	1	1
25	1	1
50	1	1
75	1	1
100	1	1
125	0.994	0.999
150	0.947	0.974
175	0.808	0.848
200	0.595	0.616
225	0.409	0.406
250	0.298	0.292
275	0.252	0.249
300	0.237	0.237
325	0.234	0.234
350	0.233	0.233
375	0.233	0.233
400	0.233	0.233

Table 4-1 Analytical Results, Aquifer Material Obtained During Drilling in 2002 (Page 1 of 3)

	Depth	Ra-226 pCi/g	Th-230 pCi/g	Uranium mg/kg
SMI BH01	15	0.4	0.32	0.631
	25	0.6	0.46	0.894
	30	0.5	0.3	0.941
	50	0.4	0.25	0.82
	55	0.4	0.22	0.772
SMI BH02	10	2.3	2.2	4.98
	15	2.6	2.6	6.98
	20	0.4	0.28	1.01
	30	0.2	0.12	0.506
	40	0.4	0.26	0.912
	50	0.5	0.3	0.894
	60	0.4	0.33	0.868
	70	0.3	0.21	0.704
	80	0.4	0.32	0.728
	85	0.38	0.27	0.714
	90	0.2	0.25	0.847
	95	0.2	0.13	0.361
	105	0.2	<0.1	0.434
	115	<0.1	<0.1	0.293
SMI BH03	5	0.92	0.67	1.18
	10			2.46
	15	0.89	0.84	1.54
	20			1.28
	25	0.47	0.25	1.02
	35	0.45	0.24	1.1
	40	0.47	0.26	1.17
	50	0.52	0.35	1.36
	55	0.55	0.36	1.42
	65	0.45	0.42	1.64
	75	0.53	0.32	1.49
	85	0.31	0.21	0.524
	95	0.16	0.11	0.327
	105	0.13	<0.1	0.326
	115	0.17	<0.1	0.293
SMI BH04	5	1.1	1.1	1.45
	10			0.78
	15	0.5	0.42	1.8
	25	0.6	0.43	1.93
	35	0.4	0.19	1.34
	45	0.4	0.37	1.39
	55	0.6	0.22	1.31
	60			1.93

Table 4-1 Analytical Results, Aquifer Material Obtained During Drilling in 2002 (Page 2 of 3)

	Depth	Ra-226 pCi/g	Th-230 pCi/g	Uranium mg/kg
SMI BH04	65	0.6	0.47	1.93
	70			0.92
	75	0.3	0.27	0.932
	85	0.3	0.35	0.73
	95	0.4	0.34	1.23
	105	0.2	0.12	0.306
	115	<0.1	0.16	0.363
SMI BH05	5	0.6	0.48	0.612
	10	0.6	0.48	0.67
	15	0.6	0.47	0.836
	20	0.4	0.36	1.67
	25	0.3	0.2	1.09
	35	0.3	0.43	1.13
	45	0.5	0.33	1.25
	55	0.4	0.34	1.05
	60	0.5	0.3	0.933
	65	0.4	0.27	0.919
	75	0.5	0.31	0.94
	85	0.3	0.31	0.972
	95	0.2	0.17	0.693
	105	0.2	0.16	0.602
	115	0.2	0.11	0.288
SWAB-40	5	0.4	0.26	0.463
	15	0.5	0.32	0.55
	25	0.5	0.42	1.59
	35	0.4	0.24	1.08
	45	0.3	0.16	0.658
SWEB-15	5	0.8	0.57	0.914
	15	0.7	0.46	1.42
	20			3.93
	25	2	0.74	3.58
	30			2.26
	35	0.7	<0.1	1.36
	45	0.46	0.33	1.1
	55	0.3	0.22	0.683
	65	0.2	0.12	0.447
	75	0.3	<0.1	0.349
	85	0.4	0.18	0.592
	90	0.5	0.33	0.81
	95	0.3	0.21	0.339
	105	0.2	0.13	0.32

Table 4-1 Analytical Results, Aquifer Material Obtained During Drilling in 2002 (Page 3 of 3)

	Depth	Ra-226 pCi/g	Th-230 pCi/g	Uranium mg/kg
SWEB-16	5	1.1	0.71	1.22
	15	0.5	0.28	0.66
	25	0.7	0.41	1.21
	35	0.6	0.44	1.1
	40	0.5	0.27	0.87
	45	0.4	0.25	0.64
	55	0.4	0.18	0.48
	60	0.4	0.18	0.56
	75	0.2	<0.1	0.54
	80	0.4	0.34	0.93
	85	0.3	0.27	0.85
	100	0.3	0.11	0.4
	110	<0.1	<0.1	0.3
	118	0.2	0.13	0.36

Table 4-2 Solid Phase Radiochemistry from Southwest Valley to Red Mule Area Combining Data from SDCP-2002 and SMI-1999 (Page 1 of 4)

Location	Depth (ft)	Ra-226 (pCi/g)	Th-230 (pCi/g)	U(nat) (mg/kg)	U(nat) (pCi/g)
SMI BH01	50	0.400	0.250	0.820	0.567
	55	0.400	0.220	0.772	0.534
	30	0.500	0.300	0.941	0.651
	15	0.400	0.320	0.631	0.437
	25	0.600	0.460	0.894	0.619
SMI BH02	90	0.200	0.250	0.847	0.586
	30	0.200	0.120	0.506	0.350
	20	0.400	0.280	1.010	0.699
	115	0.100	0.100	0.293	0.203
	105	0.200	0.100	0.434	0.300
	40	0.400	0.260	0.912	0.631
	70	0.300	0.210	0.704	0.487
	15	2.600	2.600	6.980	4.830
	60	0.400	0.330	0.868	0.601
	50	0.500	0.300	0.894	0.619
	10	2.300	2.200	4.980	3.446
	85	0.380	0.270	0.714	0.494
	95	0.200	0.130	0.361	0.250
	80	0.400	0.320	0.728	0.504
SMI BH03	75	0.500	0.300	1.500	1.038
	65	0.500	0.400	1.600	1.107
	40	0.500	0.200	1.100	0.761
	50	0.500	0.400	1.400	0.969
	105	0.100	0.100	0.300	0.208
	5	0.500	0.300	1.200	0.830
	55	0.600	0.400	1.400	0.969
	35	0.500	0.300	1.000	0.692
	85	0.300	0.200	0.500	0.346
	95	0.200	0.100	0.300	0.208
	115	0.200	0.100	0.300	0.208
	25	0.900	0.800	1.500	1.038
	15	0.900	0.700	1.200	0.830
SMI BH04	35	0.400	0.190	1.340	0.927
	15	0.500	0.420	1.800	1.246
	25	0.600	0.430	1.930	1.336
	45	0.400	0.370	1.390	0.962
	65	0.600	0.470	1.930	1.336
	95	0.400	0.340	1.230	0.851
	75	0.300	0.270	0.932	0.645
	55	0.600	0.220	1.310	0.907
	115	0.100	0.160	0.363	0.251
	85	0.300	0.350	0.730	0.505

Table 4-2 Solid Phase Radiochemistry from Southwest Valley to Red Mule Area Combining Data from SDCP-2002 and SMI-1999 (Page 2 of 4)

Location	Depth (ft)	Ra-226 (pCi/g)	Th-230 (pCi/g)	U(nat) (mg/kg)	U(nat) (pCi/g)
SMI BH04	105	0.200	0.120	0.306	0.212
	5	1.100	1.100	1.450	1.003
SMI BH05	20	0.400	0.360	1.670	1.156
	25	0.300	0.200	1.090	0.754
	95	0.200	0.170	0.693	0.480
	105	0.200	0.160	0.602	0.417
	85	0.300	0.310	0.972	0.673
	35	0.300	0.430	1.130	0.782
	45	0.500	0.330	1.250	0.865
	55	0.400	0.340	1.050	0.727
	65	0.400	0.270	0.919	0.636
	60	0.500	0.300	0.933	0.646
	75	0.500	0.310	0.940	0.650
	115	0.200	0.110	0.288	0.199
	15	0.600	0.470	0.836	0.579
	10	0.600	0.480	0.670	0.464
	5	0.600	0.480	0.612	0.424
SWAB-33	3	1.400	0.700	1.412	0.977
	8	6.000	4.800	6.843	4.735
	28	0.270	1.400	0.466	0.322
	18	0.500	2.700	0.582	0.403
	13	0.300	ns	0.757	0.524
SWAB-34	3	6.000	3.800	12.725	8.806
	18	0.700	0.300	1.150	0.796
	8	7.600	6.800	11.269	7.798
	33	0.280	2.200	1.136	0.786
SWAB-40	25	0.500	0.420	1.590	1.100
	35	0.400	0.240	1.080	0.747
	45	0.300	0.160	0.658	0.455
	5	0.400	0.260	0.463	0.320
	15	0.500	0.320	0.550	0.381
SWEB-15	35	0.700	0.100	1.360	0.941
	65	0.200	0.120	0.447	0.309
	45	0.460	0.330	1.100	0.761
	55	0.300	0.220	0.683	0.473
	25	2.000	0.740	3.580	2.477
	15	0.700	0.460	1.420	0.983
	85	0.400	0.180	0.592	0.410
	90	0.500	0.330	0.810	0.561
	105	0.200	0.130	0.320	0.221
	75	0.300	0.100	0.349	0.242
	5	0.800	0.570	0.914	0.632

Table 4-2 Solid Phase Radiochemistry from Southwest Valley to Red Mule Area Combining Data from SDCP-2002 and SMI-1999 (Page 3 of 4)

Location	Depth (ft)	Ra-226 (pCi/g)	Th-230 (pCi/g)	U(nat) (mg/kg)	U(nat) (pCi/g)
SWEB-15	95	0.300	0.210	0.339	0.235
SWEB-16	75	0.200	0.100	0.540	0.374
	110	0.100	0.100	0.300	0.208
	85	0.300	0.270	0.850	0.588
	80	0.400	0.340	0.930	0.644
	40	0.500	0.270	0.870	0.602
	118	0.200	0.130	0.360	0.249
	25	0.700	0.410	1.210	0.837
	35	0.600	0.440	1.100	0.761
	45	0.400	0.250	0.640	0.443
	100	0.300	0.110	0.400	0.277
	60	0.400	0.180	0.560	0.388
	15	0.500	0.280	0.660	0.457
	55	0.400	0.180	0.480	0.332
	5	1.100	0.710	1.220	0.844
SWEB-1	75	0.200	0.139	1.616	1.118
SWEB-2	75	0.300	0.215	1.907	1.320
	295	0.976	0.272	3.660	2.533
SWEB-3	75	0.300	0.205	5.227	3.617
SWEB-4	95	0.384	0.012	1.762	1.219
	135	0.884	0.008	1.820	1.259
SWEB-5	165	0.552	0.012	1.916	1.326
	85	0.492	0.008	1.262	0.874
	215	0.732	0.076	1.602	1.108
SWEB-6	345	0.576	0.008	1.069	0.740
	165	0.292	0.008	0.478	0.330
WN-34	115	0.208	0.028	15.142	10.479
	95	0.356	0.020	5.955	4.121
	250	1.050	0.008	1.864	1.290
TEB-1	70	9.300	153.000	40.331	27.909
	75	6.200	29.500	7.600	5.259
	67.3	23.900	735.000	24.315	16.826
TEB-2	80.5	1.500	3.300	8.547	5.914
	73.5	1.700	1.300	3.058	2.116
	63.5	2.600	48.900	38.031	26.317
	73	2.100	5.700	4.747	3.285
	58	2.500	49.500	22.437	15.526
	50.5	36.100	28.700	10.323	7.144
TEB-3	53.5	1.800	0.600	10.236	7.083
	43	2.100	3.400	4.281	2.962
	38.5	3.600	10.100	3.436	2.378
	33.5	2.300	27.600	1.718	1.189

Table 4-2 Solid Phase Radiochemistry from Southwest Valley to Red Mule Area Combining Data from SDCP-2002 and SMI-1999 (Page 4 of 4)

Location	Depth (ft)	Ra-226 (pCi/g)	Th-230 (pCi/g)	U(nat) (mg/kg)	U(nat) (pCi/g)
TEB-3	28	7.600	77.600	4.412	3.053
	23.5	84.000	116.000	2.956	2.045
WN-33D	64.2	10.000	257.000	13.104	9.068

Table 4-3 Contact List for Domestic Well Sampling

Well ID	Owner	Phone No.	Contact Response	Sampled	Source
Red Mule Acres and Parcels East					
RM-1	Jay & Wallace Jamerman P. O. Box 368 Jeffrey City, WY 82310	544-9678	2/5/02 – Yes	2/6/02	Kitchen Tap
WM-1	Charlie & Mary Roberts P. O. Box 164 Jeffrey City, WY 82310	544-2331	2/6/02 -- Yes	2/6/02	Kitchen Tap
KK-1	Derek & Shannon Kelley P. O. Box 336 Jeffrey City, WY 82310	307/540-8009	2/5/02 – Yes	2/6/02	Well house faucet
Cox #1	Jo & Betty Van Alstine 3317 Whiting Ave. Stevens Pt., WI	715/341-4131	2/5/02 – Yes	2/12/02	Well house faucet
Cox #2			2/5/02 – Yes	2/12/02	Portable Pump
Cline	Western Nuclear, Inc.	N/A	N/A	2/6/02	Kitchen Tap
Fox-1	James Tyra P. O. Box 313 Jeffrey City, WY 82310 Lessor: Mason Sutter	544-2311 544-9373	2/4/02, 2/5/02 – Yes	2/6/02	Kitchen Tap
Veach-2	Tom & Laurie Redland P. O. Box 911 Jeffrey City, WY 82310	544-9011	2/4/02 – Yes	2/6/02	Kitchen Tap
Larson #1	Mary Tuttle (Medicaid patient) c/o Canyon Hills Manor Thermopolis, WY	Unknown	POA unknown.	No	
WM-2	Gary & Nancy Bauer 707 Spencer St. Riverton, WY 82501 Lessors: Tim & Donna Kennedy	856-2073 544-2323	2/4/02, 2/5/02, 2/6/02 – Yes	2/6/02	Kitchen Tap

Table 4-3 Contact List for Domestic Well Sampling

Well ID	Owner	Phone No.	Contact Response	Sampled	Source
Bald Eagle #1	David & Jay Dee Raynor 6055 Sandi Dr., 162-13 Winnemucca, NV 89445 c/o Lorraine Raynor (Lander, WY)	775/623-2504 332-3819	2/4/02 - Yes	No, access unsafe. Well vandalized.	
Wells South of Highway					
Johnson	Hub Thompson 2329 Highway 789 Jeffrey City, WY 82310	544-9350	Yes	2/12/02	Portable pump
Stoilkov Home	Stoian 'Tony' Stoilkov 20 Thompson Drive Jeffrey City, WY 82310	544-9481	2/6/02 - Yes	2/6/02	Exterior Faucet
Stoilkov Hand			2/6/02 - Yes	No	
Stoilkov Irrig.*			2/6/02 - Yes	No	
Minahan #1*	James Minahan (Address Unknown)				
Erickson #2	Ellen (MacIntosh) Fuechuck	707/252-4788	2/5/02, 2/6/02 - No (mssg. from answering machine.)	No. (Livestock well only.)	
Townsite Wells					
Neuman's Well	Arliss Peterson (Western Nuclear, Inc. is Lessor on property)	N/A		No. Well casing or pump sanded in.	
JC #1	Jeffrey City Land Co. Bill VonHolten - contact	(307) 332-4730	2/14/02; $200 trespass fee. (Casing fractured.)	No, declined fee, unsafe.	
Home #1	Steven G. Harrison P. O. Box 4406 Gillette, WY 82717	Unknown	No contact made, unlisted in telephone directory.	No	

* These may be the same well, Minahan #1 is from State Engineers records. Other Stoilkov wells may not be registered.

Table 4-4 Analytical Results of Groundwater, Samples from Drilling, 2002 (Page 1 of 2)

Location	Sample depth, ft.	Date Sampled	Alkalinity as CaCO3 (mg/L)	Ammonia as N (mg/L)	Nitrate+Nitrite as N (mg/L)	TOC (mg/L)	TDS, Calculated (mg/L)	TDS @ 180 (mg/L)	A/C Balance (± 5) %	Al (mg/L)	Anions (meq/L)
SMI BH01	55	1/13/02	87	<0.05	1.8		117.18	284	-1.47	<0.1	2.17
	65	1/13/02	82	<0.05	1.66		109.90	192	-1.05	<0.1	2.03
	75	1/13/02	71	<0.05	1.21		87.53	191	0.01	<0.1	1.62
	85	1/13/02	72	<0.05	1.06		93.57	168	0.81	<0.1	1.71
	95	1/13/02	75	<0.05	1.15		96.56	150	0.38	<0.1	1.78
SMI BH02	36	1/13/02	164	<0.05	0.96	3.45	255.97	303	0.54	<0.1	4.59
	56	1/13/02	156	<0.05	1.16	3.17	227.97	378	0.51	<0.1	4.15
	65	1/13/02	154	<0.05	1.1	1.24	227.53	273	1.31	0.3	4.12
	75	1/13/02	158	<0.05	1.12	0.76	232.20	273	-0.36	<0.1	4.27
	85	1/14/02	147	<0.05	1.14	1.13	218.62	253	1.24	<0.1	3.96
	95	1/14/02	156	<0.05	1.07	1.47	231.52	283	2.64	<0.1	4.14
	105	1/14/02	159	<0.05	0.97	2.33	240.82	330	1.70	<0.1	4.34
	115	1/14/02	152	<0.05	1.08	1.36	223.90	279	1.42	<0.1	4.04
	105	1/14/02	156	<0.05	0.95	2.55	243.16	279	1.48	<0.1	4.37
SMI BH03	36	1/15/02	130	0.17	1.48	3.24	234.44	265	0.01	<0.1	4.14
	55	1/16/02	140			2.91		273			
	75	1/16/02	130	<0.05	1.63	1.68	207.18	226	-0.51	<0.1	3.72
	85	1/16/02	139	<0.05	1.45	0.94	208.23	225	0.38	<0.1	3.77
	95	1/16/02	140	<0.05	1.55	0.80	210.80	261	0.22	<0.1	3.83
	105	1/16/02	147	<0.05	0.99	0.71	224.79	268	1.11	<0.1	4.07
	115	1/16/02	149	0.16	0.59	0.50	216.74	248	0.50	<0.1	3.96
SMI BH04	55	1/16/02	162	<0.05	1.26	2.43		299		<0.1	
	65	1/16/02	158	<0.05	1.34	1.14		241		<0.1	
	75	1/16/02	152	<0.05	1.29	0.54		245		<0.1	
	85	1/16/02	147	<0.05	1.2	0.58		249		<0.1	
	95	1/16/02	148	<0.05	1.05	0.56		241		<0.1	
	105	1/16/02	149	<0.05	0.9	0.52		251		<0.1	
	115	1/16/02	152	<0.05	0.59	<.5		261		<0.1	

Table 4-4 Analytical Results of Groundwater, Samples from Drilling, 2002 (Page 2 of 2)

Location	Sample depth, ft.	Date Sampled	Alkalinity as CaCO3 (mg/L)	Ammonia as N (mg/L)	Nitrate+Nitrite as N (mg/L)	TOC (mg/L)	TDS, Calculated (mg/L)	TDS @ 180 (mg/L)	A/C Balance (± 5) %	Al (mg/L)	Anions (meq/L)
SMI BH05	55	1/17/02	160			3.92		272		<0.1	
	75	1/17/02	154	<0.05	1.14	2.97		217		<0.1	
	85	1/17/02	150	<0.05	1.06	0.95		255		<0.1	
	95	1/17/02	148	<0.05	1.09	0.67		273		<0.1	
	105	1/17/02	142	<0.05	0.95	<.5		248		<0.1	
	115	1/17/02	147	<0.05	0.94	0.74		246		<0.1	
	105	1/17/02	144	<0.05	0.91	<.5		249		<0.1	
SWAB40	36	1/12/02	134	0.08	1.03	9.16	206.27	239	0.20	<0.1	3.74
	45	1/12/02	142	<0.05	0.69	1.80	217.77	240	2.21	<0.1	3.88
SWEB15	80	1/8/02	137	0.07	0.55	9.36		270		<0.1	
	95	1/8/02	146	0.08	0.49	2.92		244		<0.1	
	105	1/8/02	149	<0.05	0.44	2.12		238		<0.1	
	115	1/8/02	152	<0.05	0.44	0.83		239		<0.1	
SWEB16	40	1/10/02	103	<0.05	1.66	8.74		224		<0.1	
	60	1/10/02	132	0.06	1.66	7.76		222		<0.1	
	80	1/10/02	137	0.11	1.78	11.60		289		<0.1	
	90	1/10/02	143	0.1	0.89	3.85		233		<0.1	
	100	1/10/02	144	<0.05	1.28	1.90		237		<0.1	
	110	1/10/02	154	<0.05	1.08	1.14		241		<0.1	
	118	1/10/02	151	<0.05	0.94	1.00		262		<0.1	
	40	1/10/02	104	0.08	1.67	9.05		208		<0.1	
	55	1/10/02								<0.1	

Table 4-5 Analytical Results from Groundwater, Samples from Wells (Page 1 of 4)

Location	Date Sampled	Depth, ft	Easting	Northing	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	TOC mg/L	TDS mg/L	HCO3 mg/L	Ca mg/L
Cline	06-Feb-02		19056.27	972.59	<0.5	1.50	0.529	234	165	50.7
Cox-1	12-Feb-02	89.8	17990.6	2012.1	<0.5	1.24			160	35.08
Cox-2	12-Feb-02		18223.6	1273.8	<0.5	1.12		252	190	36.5
Fox-1	06-Feb-02	40	19377.36	959.19	<0.5	0.88	<0.5	226	170	47.5
Johnson	12-Feb-02	65	15351.59	-21.893	<0.5	2.87		208	151	31.9
KK-1	06-Feb-02	57	17048.46	955.22	<0.5	3.16	1.145	293	185	59.5
RM-1	06-Feb-02	60	15808.7	1179.6	<0.5	3.95	2.046	396	257	81.0
Stoilkov Home	06-Feb-02		16184.67	-283.28	<0.5	1.30	0.541	243	173	51.7
SWAB-1	07-Feb-02	28	7401.5	2654.5	<0.5	84.50			289	337
SWAB-10	04-Feb-02	29.9	7556.836	1493.015	<0.5	1.69			200	
SWAB-14	04-Feb-02	18.1	2945.734	3580.138	<0.5	0.23	0.678	356	178	74.9
SWAB-15	05-Feb-02	22.5	9074.378	1413.004	<0.5	0.72			309	
SWAB-17	07-Feb-02	38.5	8206.33	2370.382	<0.5	4.93			172	82
SWAB-2	05-Feb-02	28.3	6684.8	3582.8	96.7	113.00			332	
SWAB-21	04-Feb-02	13.5	3045.316	5730.582	<0.5	<0.1	2.212	716	248	99.4
SWAB-25	04-Feb-02	16	2308.561	4906.15	<0.5	0.63	6.147	964	346	76.3
SWAB-26	04-Feb-02	25	350.6	5571.7	<0.5	1.70	1.145	260	160	46.7
SWAB-28	07-Feb-02	33.5	11009.9	1281.8	<0.5	1.26			200	53.1
SWAB-29	07-Feb-02	18.5	11999.3	1730.3	<0.5	<0.1			221	61.6
SWAB-30	05-Feb-02	23.5	4591.905	3679.661	<0.5	0.77	1.017	287	181	61.2
SWAB-31	06-Feb-02	40	13847.02	1306.919	<0.5	1.13	0.693	234	190	56.2
SWAB-32	06-Feb-02	34	13783.04	-64.251	<0.5	1.15	1.722	324	213	66.0
SWAB-33	06-Feb-02	29	17782.78	2417.2	<0.5	0.36	5.354	501	281	72.4
SWAB-34	06-Feb-02	33	15564.22	2943.62	<0.5	0.85	1.158	255	192	58.8
SWAB-35	04-Feb-02	20	3930.41	4845.79	<0.5	0.58	0.514	302	184	66.5
SWAB-39	06-Mar-02	44.1	14661.99	1225.46	<0.5	1.48			197	55.2
SWAB-4	04-Feb-02	18.8	4674.3	6651.4	10.0	40.20	3.789	1330	258	241.0
SWAB-5	04-Feb-02	20.4	5079.4	5762.4	5.2	14.90	1.652	679	201	113.0
SWAB-6	04-Feb-02	22.92	4911.4	2208.2	<0.5	1.12			193	

Table 4-5 Analytical Results from Groundwater, Samples from Wells (Page 2 of 4)

Location	Date Sampled	Depth, ft	Easting	Northing	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	TOC mg/L	TDS mg/L	HCO3 mg/L	Ca mg/L
SWAB-7	07-Feb-02	20.3	9963.6	2100.8	<0.5	4.88			197	71.7
SWEB-10	04-Feb-02	231	5102.1	5783.5	<0.5	1.45	<0.5	435	177	92.4
SWEB-12	07-Feb-02	494	9952.2	2078.1	<0.5	0.43			182	51.9
SWEB-13	05-Feb-02	555	4598.663	3705.72	<0.5	<0.1	<0.5	272	39.7	22.7
SWEB-14	11-Feb-02	109.5	11974.4	1743.5	<0.5	<0.1			201	54.4
SWEB-15	06-Mar-02	99.59	14662.06	1251.2	<0.5	0.52			188	52.4
SWEB-16	06-Mar-02	99.75	13840.21	1329.51	<0.5	0.90			178	52.8
SWEB-6	05-Feb-02	396	6706.2	3611.3	0.8	<0.1			100	
SWEB-8	11-Feb-02	195	7417.342	2676.008	<0.5	0.38			178	66.6
SWEB-9	11-Feb-02	416	8167.5	2389.8	<0.5	<0.1			60.2	3.2
Veach-2	06-Feb-02	75	15750	1600	<0.5	3.65	1.381	312	218	63.8
WM-1	06-Feb-02	65	16081	1980.83	<0.5	1.91	1.124	289	215	64.7
WM-2	06-Feb-02	65	16099	1687	<0.5	2.09	0.956	302	217	62.4
SWAB-15	15-Apr-02					1.01		380		
SWAB-37	15-Apr-02					0.4		249		
SWAB-38	15-Apr-02					0.39		271		

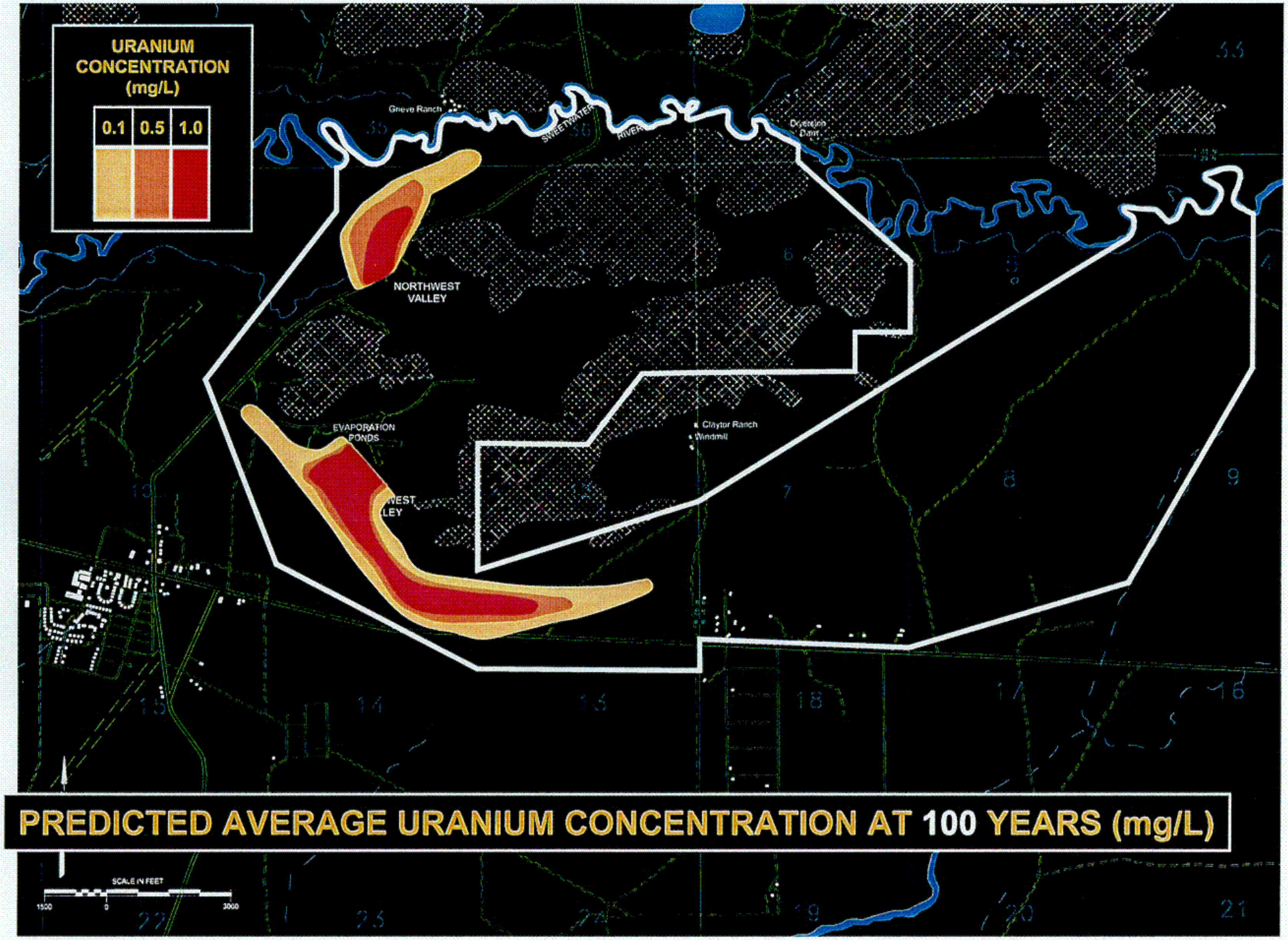
Table 4-5 Analytical Results from Groundwater, Samples from Wells (Page 3 of 4)

Location	Date Sampled	Depth, ft	CO3 mg/L	Cl Mg/L	Mg mg/L	Mn mg/L	K Mg/L	Ra-226 PCi/L	Ra-228 pCi/L	Na mg/L	SO4 mg/L	U mg/L
Cline	06-Feb-02		<1	2.63	6.50	<0.01	4.04	<0.2	<1	21.7	38.8	0.040
Cox-1	12-Feb-02	89.8	<1	6.6	5.7	<0.01	4.7	<0.2		30.3	32.1	0.031
Cox-2	12-Feb-02		<1	2.45	5.94	<0.01	4.04	<0.2		18.0	39.0	0.053
Fox-1	06-Feb-02	40	<1	4.66	7.05	<0.01	5.10	0.5		20.7	33.0	0.027
Johnson	12-Feb-02	65	<1	6.48	4.62	<0.01	3.23	<0.2		15.3	24.8	<0.0003
KK-1	06-Feb-02	57	<1	10.70	9.07	<0.01	5.16	<0.2		28.6	49.1	0.073
RM-1	06-Feb-02	60	<1	17.20	12.40	<0.01	5.21	<0.2		39.0	62.2	0.314
Stoilkov Home	06-Feb-02		<1	5.85	7.21	<0.01	4.50	<0.2	<1	21.8	37.8	0.027
SWAB-1	07-Feb-02	28	<1	35.3	85.6	<0.01	8.4	<0.2		92.2	773.0	1.240
SWAB-10	04-Feb-02	29.9	<1	10.4		<0.01		<0.2	2		41.5	0.056
SWAB-14	04-Feb-02	18.1	<1	29.60	9.57	<0.01	5.73	<0.2	<1	29.9	83.6	0.045
SWAB-15	05-Feb-02	22.5	<1	26.7		<0.01		<0.2	<1		70.5	0.106
SWAB-17	07-Feb-02	38.5	<1	11.9	13.1	0.0139	6	0.3		37.7	43.4	0.104
SWAB-2	05-Feb-02	28.3	<1	47.2		6.45		3.6	6		1320.0	1.390
SWAB-21	04-Feb-02	13.5	<1	30.60	16.70	<0.01	8.12	<0.2	<1	107.0	266.0	0.107
SWAB-25	04-Feb-02	16	4.5	60.20	9.30	<0.01	7.17	<0.2	2.2	227.0	323.0	0.155
SWAB-26	04-Feb-02	25	<1	19.40	5.67	<0.01	6.51	<0.2	<1	27.7	28.2	0.016
SWAB-28	07-Feb-02	33.5	<1	7.6	7.4	<0.01	4.2	0.5		22.5	27.1	0.049
SWAB-29	07-Feb-02	18.5	<1	5.7	12	<0.01	3.5	<0.2		6.4	112.0	0.018
SWAB-30	05-Feb-02	23.5	<1	8.65	8.02	0.0212	5.61	<0.2	<1	24.1	55.4	0.032
SWAB-31	06-Feb-02	40	<1	10.10	6.45	<0.01	3.19	<0.2	<1	23.6	29.5	0.033
SWAB-32	06-Feb-02	34	<1	13.50	8.86	<0.01	5.32	<0.2	<1	34.1	56.9	0.163
SWAB-33	06-Feb-02	29	<1	29.70	12.80	<0.01	6.46	<0.2	<1	81.4	117.0	0.337
SWAB-34	06-Feb-02	33	<1	7.89	8.03	<0.01	3.60	<0.2	<1	24.6	39.7	0.054
SWAB-35	04-Feb-02	20	<1	10.60	8.15	<0.01	6.32	<0.2	<1	21.9	60.5	0.032
SWAB-39	06-Mar-02	44.1	<1	11	9.7	0.0134	3.3	<0.2	<1	24.4	35.4	0.105
SWAB-4	04-Feb-02	18.8	<1	36.30	55.30	<0.01	19.60	2.8	4	58.5	521.0	1.140
SWAB-5	04-Feb-02	20.4	<1	31.50	30.40	0.831	12.80	0.5	1.5	42.5	224.0	0.434
SWAB-6	04-Feb-02	22.92	<1	18		<0.01			<1		66.3	0.045
SWAB-7	07-Feb-02	20.3	<1	4	6.6	<0.01	4.1	0.3		12.3	34.6	0.082

Table 4-5 Analytical Results from Groundwater, Samples from Wells (Page 4 of 4)

Location	Date Sampled	Depth, ft	CO3 mg/L	Cl Mg/L	Mg mg/L	Mn mg/L	K mg/L	Ra-226 pCi/L	Ra-228 pCi/L	Na mg/L	SO4 mg/L	U mg/L
SWEB-10	04-Feb-02	231	<1	25.60	13.50	0.143	7.58	<0.2	2.1	25.2	129.0	0.042
SWEB-12	07-Feb-02	494	<1	18.60	8.00	<0.01	7.10	<0.2		32.5	55.2	0.025
SWEB-13	05-Feb-02	555	<1	96.00	5.80	0.0296	7.73	<0.2	<1	64.2	47.2	<0.0003
SWEB-14	11-Feb-02	109.5	<1	6.50	8.20	0.207	5.90	<0.2		24.5	45.7	0.017
SWEB-15	06-Mar-02	99.59	<1	4.80	7.20	<0.01	3.70	<0.2	<1	23.6	42.0	0.022
SWEB-16	06-Mar-02	99.75	<1	6.40	6.60	<0.01	3.50	<0.2	<1	23.8	44.5	0.035
SWEB-6	05-Feb-02	396	1.7	16.20		0.0733		<0.2	<1		<1	0.001
SWEB-8	11-Feb-02	195	<1	34.20	9.70	<0.01	6.70	<0.2		27.0	61.4	0.018
SWEB-9	11-Feb-02	416	4.1	10.50	6.10	<0.01	6.40	0.4		20.7	16.0	<0.0003
Veach-2	06-Feb-02	75	<1	11.60	9.59	<0.01	4.26	<0.2	<1	34.1	43.8	0.170
WM-1	06-Feb-02	65	<1	9.54	9.18	<0.01	4.71	<0.2	<1	28.8	44.2	0.165
WM-2	06-Feb-02	65	<1	9.58	9.01	<0.01	4.62	<0.2		30.7	44.0	0.155
SWAB-15	15-Apr-02			22.6							64.5	.0868
SWAB-37	15-Apr-02			7.29							47.5	0.103
SWAB-38	15-Apr-02			7.39							55.7	0.0415

FIGURES

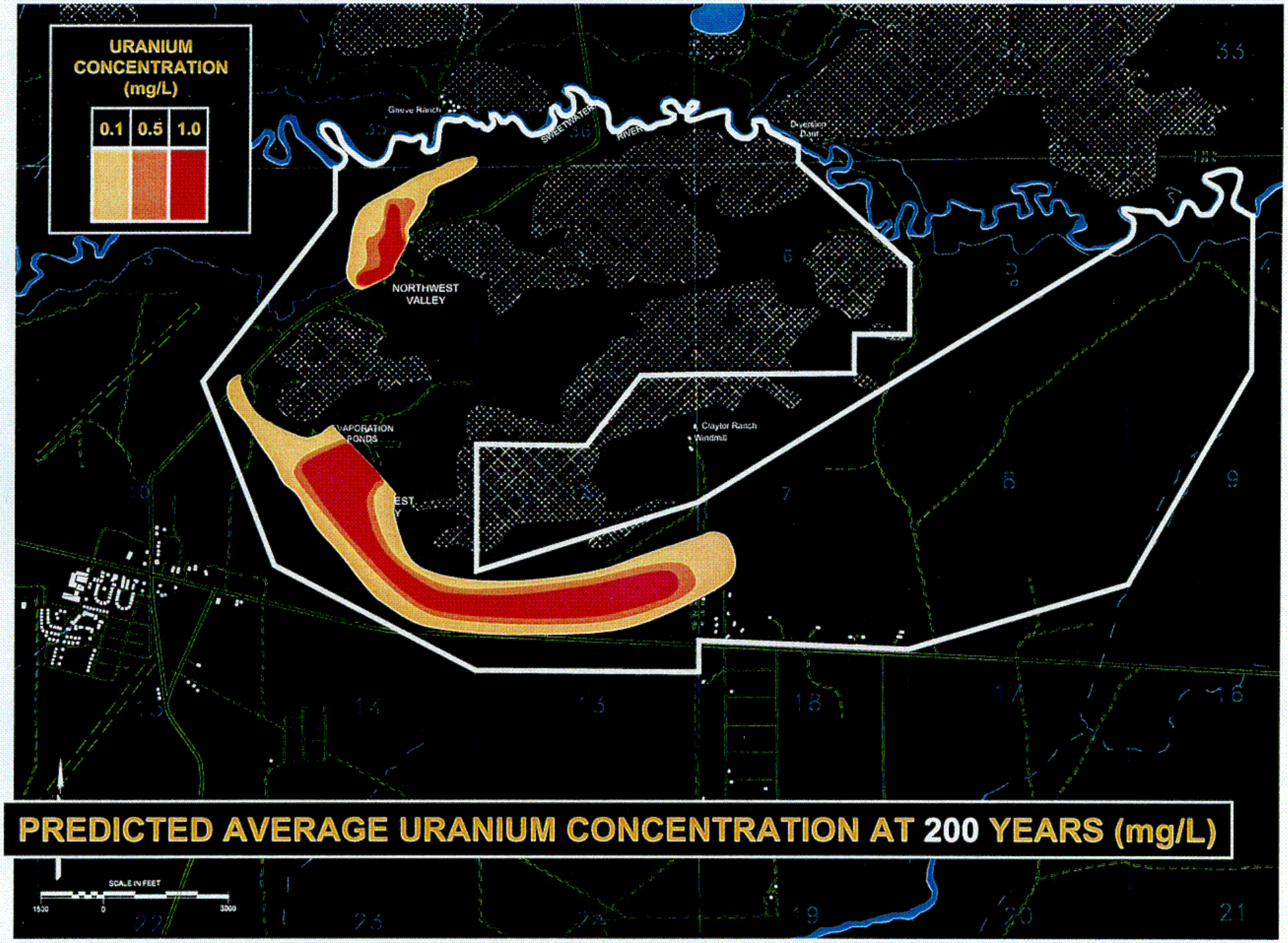


C-01

SHEPHERD MILLER
INCORPORATED

FIGURE 1-1
PREDICTED AVERAGE URANIUM CONCENTRATION AT 100 YEARS

Date: MAY 2002
Project: P:\03-347\RAI RESP 2002
File: LOU FIGS.ppt



C-02

SHEPHERD MILLER
INCORPORATED

FIGURE 1-2
PREDICTED AVERAGE URANIUM CONCENTRATION AT 200 YEARS

Date:	MAY 2002
Project:	P:\03-347\RAI RESP 2002
File:	LOU FIGS.ppt

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

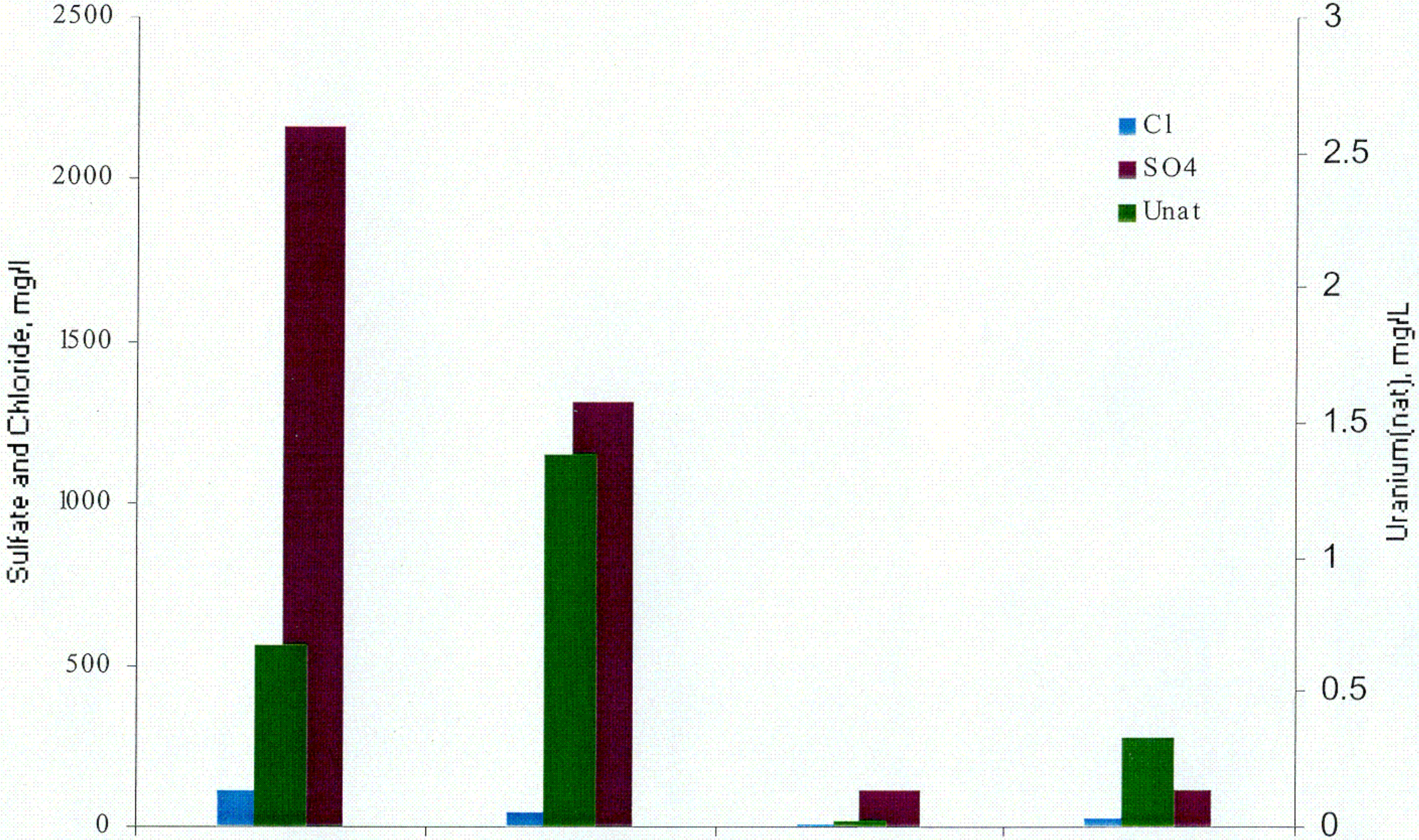
FIGURE 1-3

URANIUM (nat) AQUEOUS AND SOLID ALONG CROSS SECTION G'-G"

WITHIN THIS PACKAGE

NOTE: Because of these page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

D-1



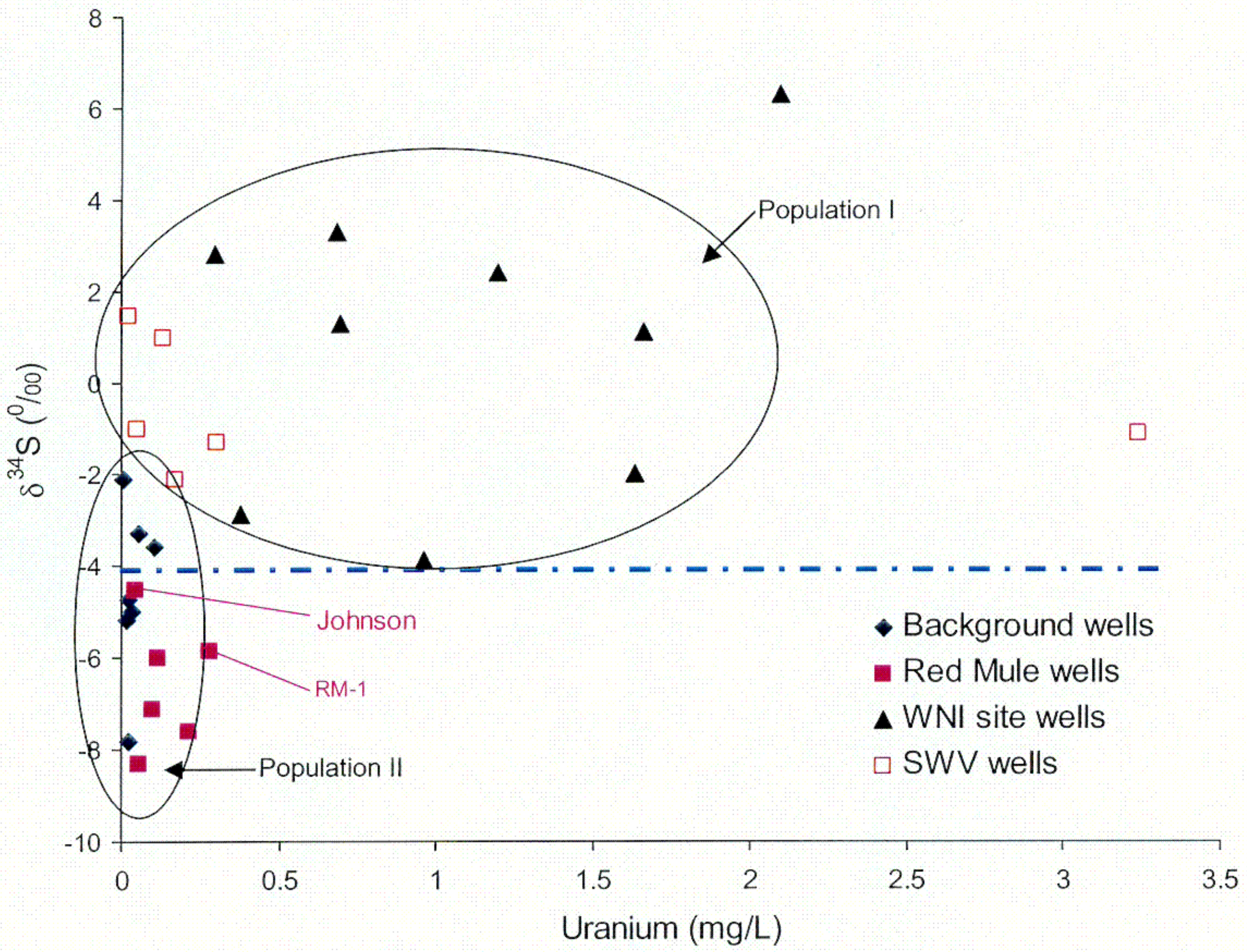
C-03

SHEPHERD MILLER
INCORPORATED

FIGURE 1-4
AQUEOUS PHASE CHLORIDE, SULFATE, URANIUM LEVELS AT SELECT LOCATIONS, FROM MILL SITE TO RED MULE AREA

Date: MAY 2002
Project: P:\03-347\RAI RESP 2002
File: LOU FIGS.ppt

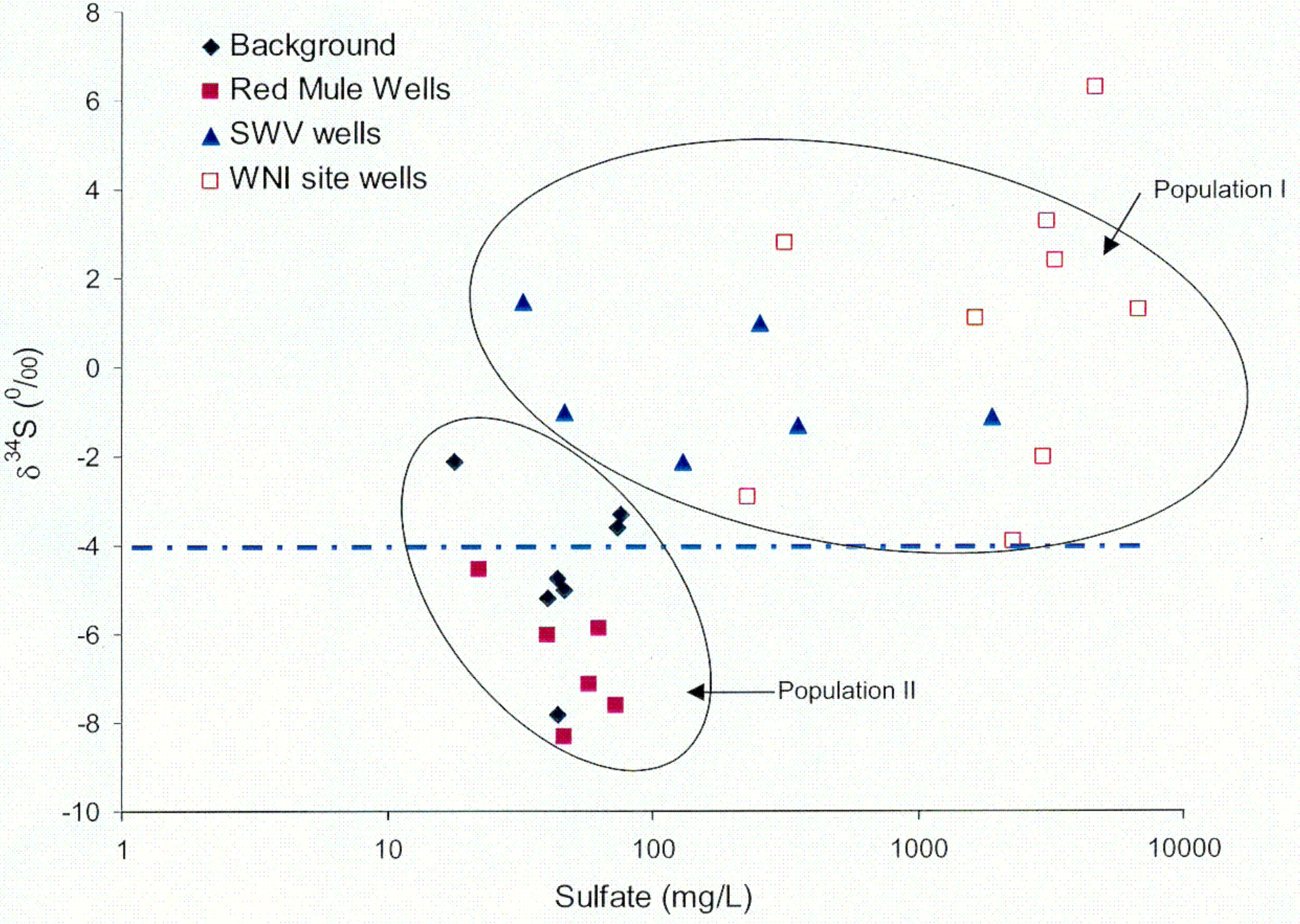
C-04



SHEPHERD MILLER
INCORPORATED

FIGURE 1-5
DISTRIBUTION OF $\delta^{34}S$ VERSUS URANIUM CONCENTRATION IN WELLS FROM THE WNI SITE AND THE SWV FLOODPLAIN

Date:	MAY 2002
Project:	P:\03-347\RAI RESP 2002
File:	LOU FIGS.ppt

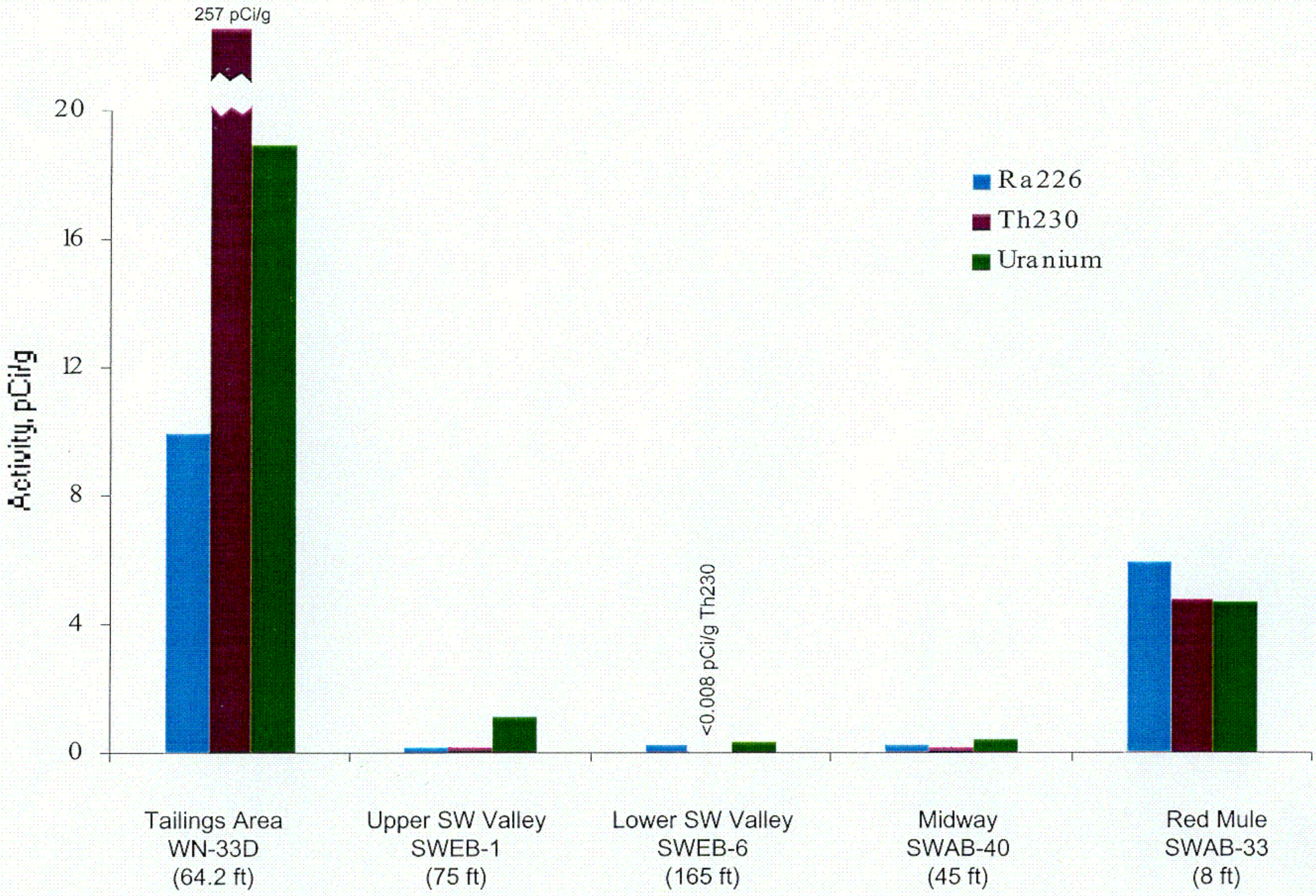


C-05

SHEPHERD MILLER
INCORPORATED

FIGURE 1-6
DISTRIBUTION OF $\delta^{34}S$ VERSUS SULFATE CONCENTRATION IN WELLS FROM THE WNI SITE AND THE SWV FLOODPLAIN

Date:	MAY 2002
Project:	P:\03-347\RAI RESP 2002
File:	LOU FIGS.ppt



C-06

SHEPHERD MILLER
INCORPORATED

FIGURE 1-7
SOLID PHASE Ra226, Th230, URANIUM FROM SELECT LOCATIONS, WESTERN NUCLEAR SPLIT ROCK SITE, JEFFREY CITY, WYOMING

Date:	MAY 2002
Project:	P:\03-347\RAI RESP 2002
File:	LOU FIGS.ppt

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

FIGURE 1-8

URANIUM (nat) AQUEOUS AND SOLID ALONG CROSS SECTION G°-G"

WITHIN THIS PACKAGE

NOTE: Because of these page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

D-2

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

FIGURE 1-9

Ra-226 AND Th-230 SOLID ALONG CROSS SECTION G'-G"

WITHIN THIS PACKAGE

NOTE: Because of these page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

D-3

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

FIGURE 1-10

Ra-226 AND Th-230 SOLID ALONG CROSS SECTION G°-G"

WITHIN THIS PACKAGE

NOTE: Because of these page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

D-4

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

FIGURE 2-1

SITE INVESTIGATION LOCATIONS

2002

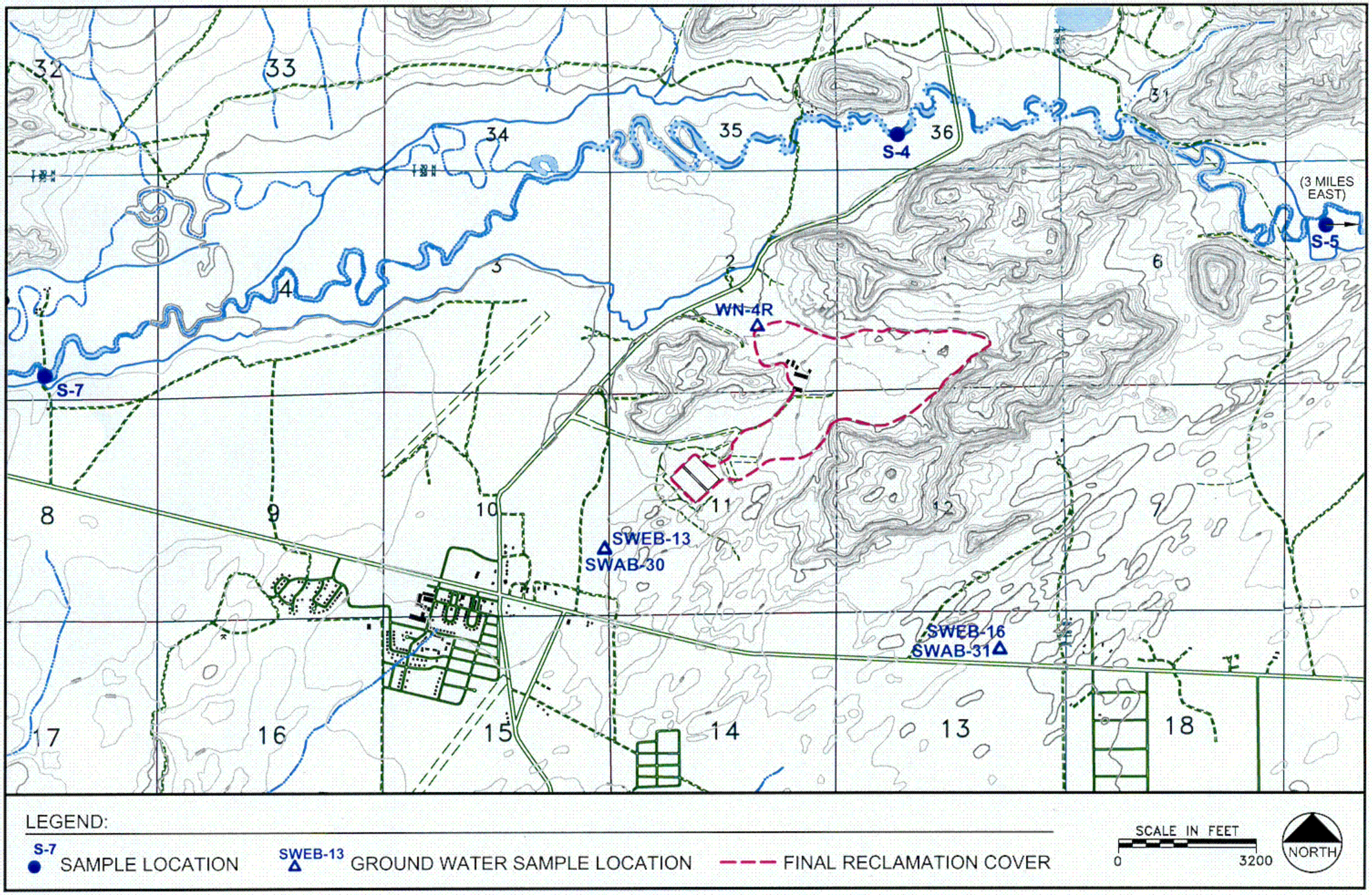
SPLIT ROCK SITE

JEFFREY CITY, WYOMING

WITHIN THIS PACKAGE

NOTE: Because of these page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

D-5

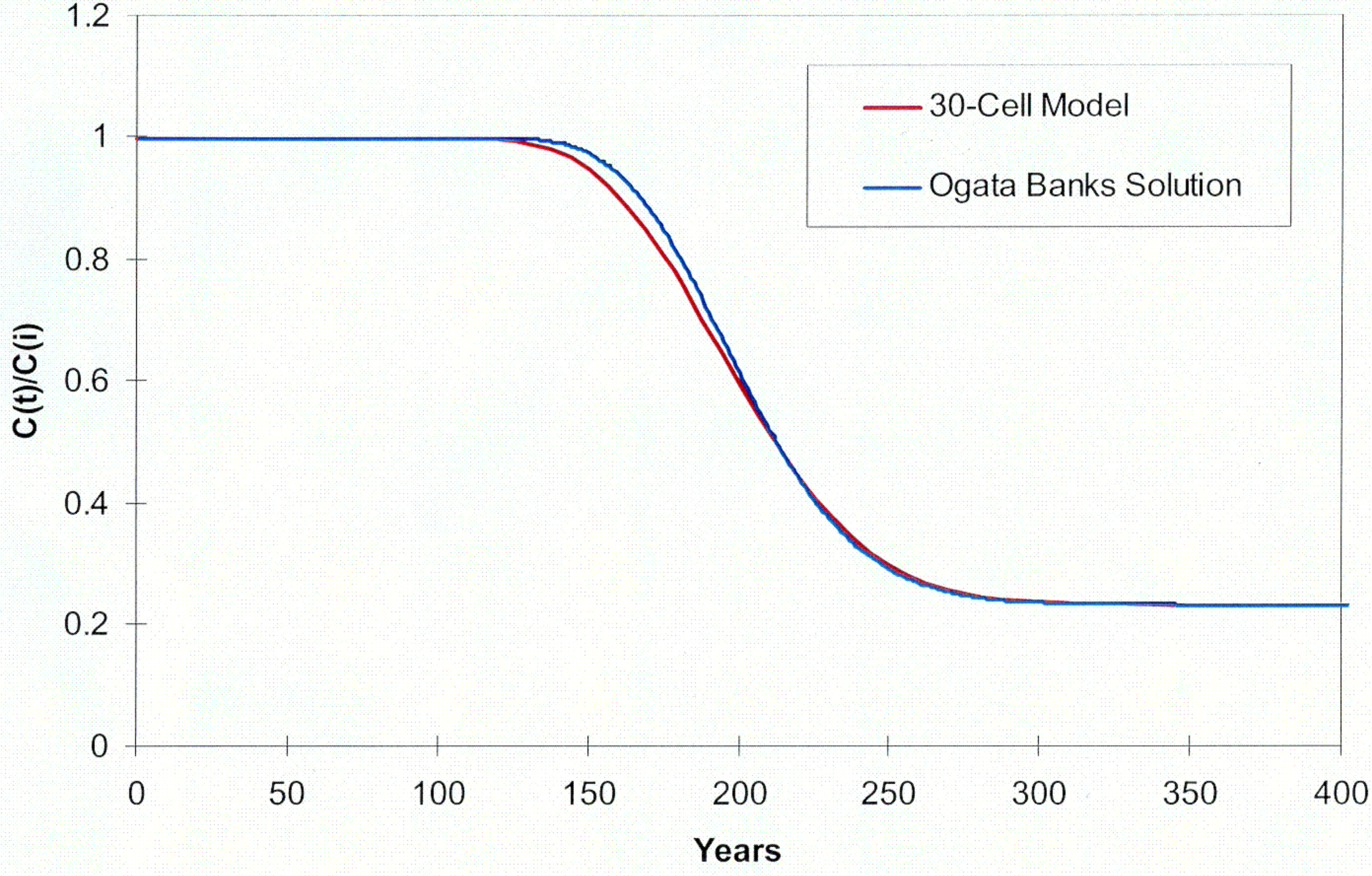


SHEPHERD MILLER

FIGURE 2-2
PROPOSED SURFACE WATER AND GROUND WATER SAMPLING LOCATIONS FOR LONG TERM MONITORING

Date:	MAY 2002
Project:	03-347\2002
File:	LNG-TERM.dwg

C-07

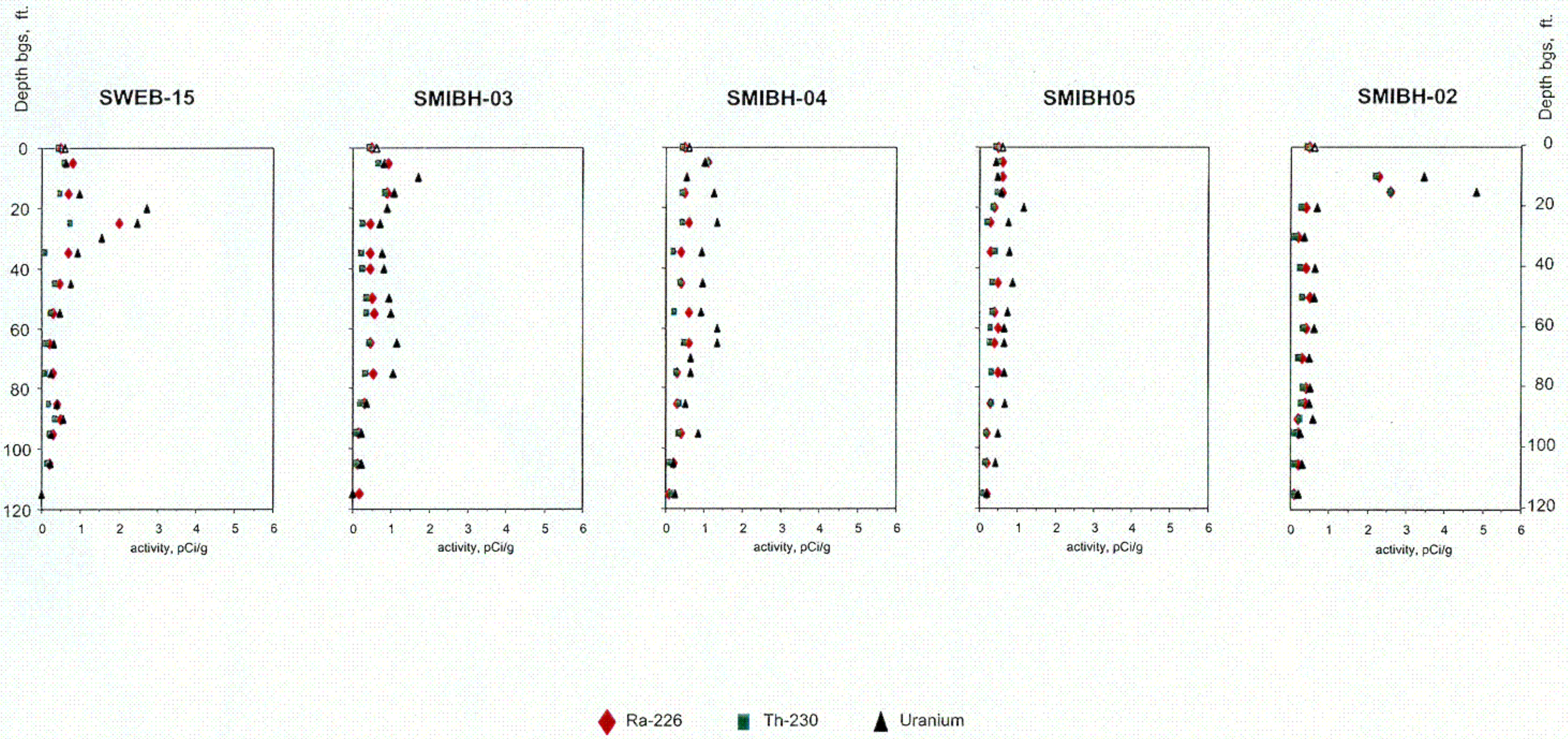


SHEPHERD MILLER
INCORPORATED

FIGURE 3-1
COMPARISON OF 30-CELL MODEL AND OGATA-BANKS SOLUTION

Date: MAY 2002
Project: P:\03-347\RAI RESP 2002
File: LOU FIGS.ppt

C-08

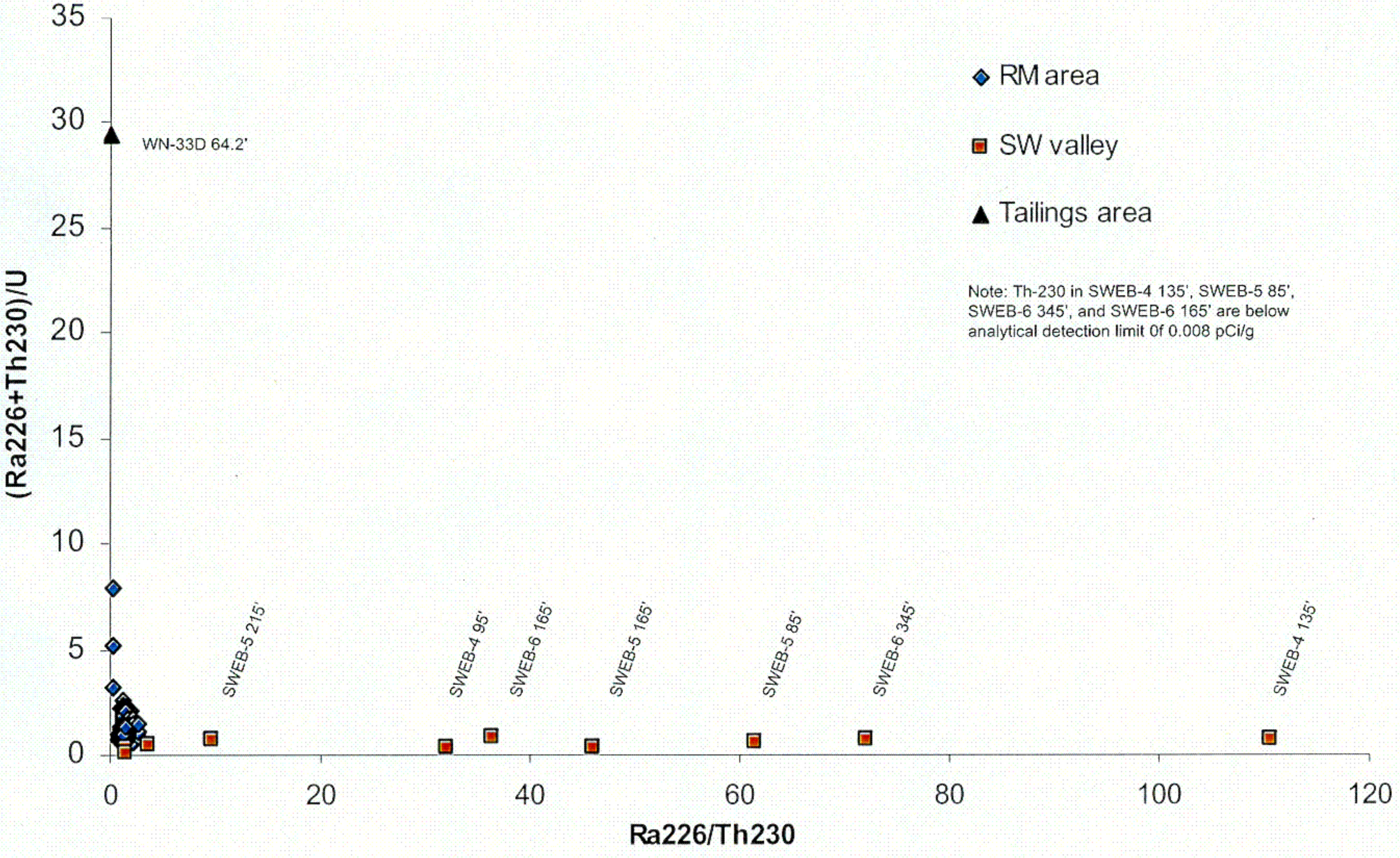


C-09

SHEPHERD MILLER
INCORPORATED

FIGURE 4-1
RADIONUCLIDES IN SOLID PHASE IN 2002 SITE INVESTIGATION LOCATIONS, RED MULE AREA

Date: MAY 2002
Project: P:\03-347\RAI RESP 2002
File: LOU FIGS.ppt

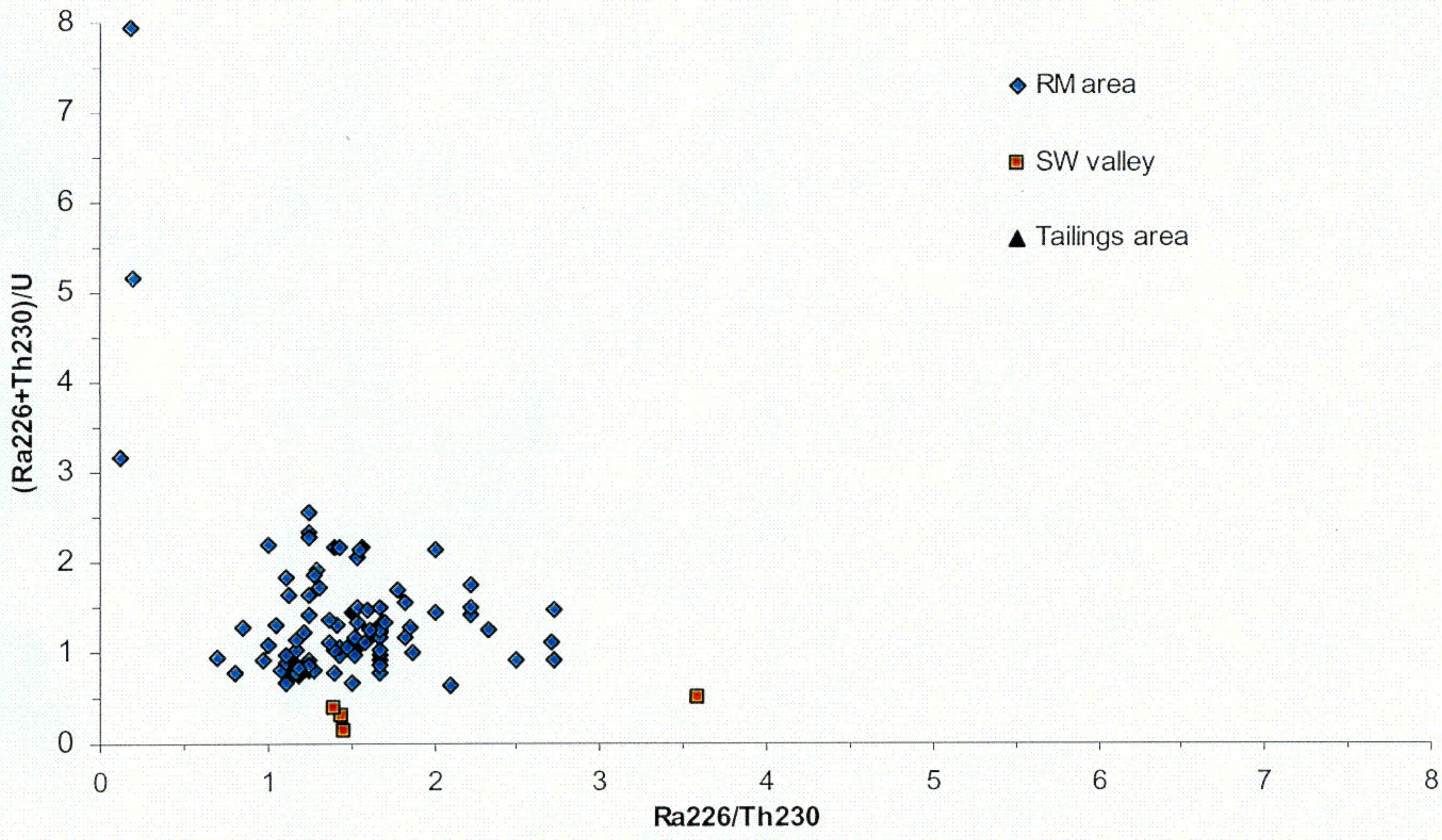


SHEPHERD MILLER
INCORPORATED

FIGURE 4-2a
Ra226+Th230/U vs Ra226+Th230 IN SOLID PHASE FROM TAILINGS AREA, SW VALLEY AND RED MULE AREA

Date:	MAY 2002
Project:	P:\03-347\RAI RESP 2002
File:	LOU FIGS.ppt

C-10

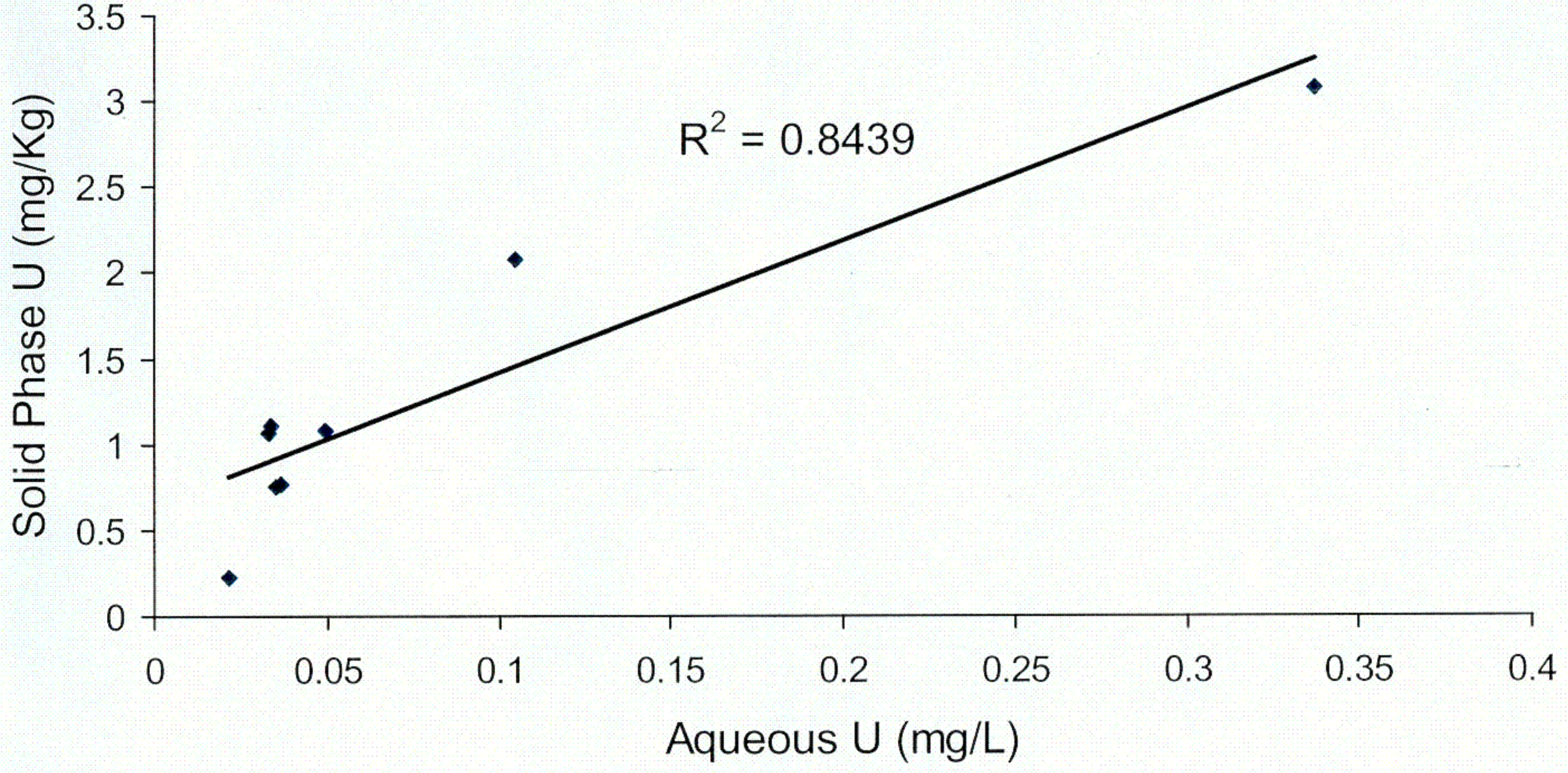


C-11

SHEPHERD MILLER
INCORPORATED

FIGURE 4-2b
Ra226+Th230/U vs Ra226+Th230 IN SOLID PHASE FROM
TAILINGS AREA, SW VALLEY AND RED MULE AREA

Date: MAY 2002
Project: P:\03-347\RAI RESP 2002
File: LOU FIGS.ppt



SHEPHERD MILLER
INCORPORATED

FIGURE 4-3
AQEOUS VERSUS SOLID PHASE URANIUM CONCENTRATIONS IN THE RED MULE AREA

Date:	MAY 2002
Project:	P:\03-347\RAI RESP 2002
File:	LOU FIGS.ppt

C-12

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

FIGURE E-3-2

MEASURED WATER TABLE ELEVATION (FEET)

(1996-1998 DATA)

REVISION 0

WITHIN THIS PACKAGE

NOTE: Because of these page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

D-6