As discussed in Section 2.3 and detailed in Appendix I, there are no current adverse impacts to public health and safety and the environment. Additionally, ground water modeling indicates that there will be no adverse impact to any environmental receptors in the future. However, the exposure assessment does indicate that there is a potential future impact to public health under a domestic drinking water pathway scenario. The four alternatives described above and detailed in Appendix H address this potential future pathway scenario.

Each of the four alternatives differ in scope and approach utilized to provide protection for the potential future drinking water pathway. However, all alternatives provide the same level of protection. The concentrations of the COCs at the potential POEs are essentially the same for all of the alternatives–background. Ground water is controlled by passive, active and/or institutional controls for each of the potential alternatives so that ground water that could be accessed for drinking water would not be significantly impact from the tailings seepage. Background concentrations are, by definition, protective.

Traditionally, ALARA is defined as achieving concentrations of non-threshold constituents that are as low a reasonably achievable given the site specific costs and benefits of achieving that reduction. As stated above, each of the four potential alternatives that were developed provide essentially the same concentrations of constituents from the tailings (radiological and non-radiological) at the potential POEs. The concentrations at the POEs are background. Therefore, the traditional ALARA approach could not be used. However, an alternative ALARA concept was used in that the alternatives are evaluated using a cost/benefit evaluation where the benefit is not measured as a reduction in concentrations below an acceptable level at a potential exposure point, but rather the ability to maintain the potential drinking water pathway scenario over land areas. The major difference between the alternatives is the tradeoff of larger areas of institutional controls with active treatment, which reduces the area over which controls are required but increases the economic and non-economic costs.

A discussion of the costs and benefits for each of the alternatives is provided in Sections 3.3 and 3.4 below.

## 3.3 Corrective Action Costs

Costs for each of the potential alternatives were determined and are detailed in Appendix H. These costs are divided in economic and non-economic costs. The economic costs were developed by estimating capital, operating and maintenance, waste disposal, and decommissioning costs. Non-economic costs are in the categories of potential risk to workers, potential impacts to the environment, and water use. Administrative costs associated with permitting are expected for all of the alternatives. Those costs are not included in the evaluation since they are small relative to the overall economic costs of each alternative and should be close to the same for each alternative. A summary of the costs for each alternative is provided below and presented on Table 15.

### 3.3.1 Alternative No. 1 - Institutional Control and Alternate Water Supply

Costs for Alternative No. 1 are associated with installation of an alternative water supply for the current users of ground water for domestic drinking water. It is estimated that the alternative water supply might be required in approximately 100 years. Monitoring up gradient of the existing wells will determine if and when an alternative supply is necessary. A total cost of $114,000 is estimated to be required to install this system. Details of the cost estimate are included in Appendix H. There are little or no non-economic costs associated with Alternative No. 1. There will be little or no environmental impacts, risks to workers, or use of water resources.

### 3.3.2 Alternative No. 2 - Hydraulic Diversion With Institutional Control

The costs associated with Alternative No. 2 are for the installation and perpetual operation of the hydraulic diversion system. The economic costs for this alternative are estimated at approximately $18 million. There will be minimal environmental impacts associated with the installation and operation of the hydraulic diversion system. Potential impacts to worker safety, which relate to constructing and perpetual operation and maintenance of the hydraulic diversion system, are considered low and consist of an estimated probability of occupational fatality of $4.3 \times 10^{-3}$ and 4.8 lost time work injuries over the 1,000-year design life of the system. The major non-economic cost for this alternative is the perpetual use of water resources. This alternative requires 500 gpm that would be obtained from pumping a supplemental water supply potentially located to the south of the site. Of the 500 gpm, roughly one-half would become mixed with the site-derived waters. The other one-half would remain unimpacted and flow back into the regional flow pattern.

### 3.3.3 Alternative 3 - Focused Pumping With Institutional Control

The costs associated with Alternative No. 3 are related to the forced pumping and evaporation systems. The total economic cost of this alternative is approximately $108 million. The non-economic costs include the environmental impacts associated with constructing the injection and recovery system and for the lined evaporation ponds which would cover approximately 1,000 acres. The evaporation pond construction would involve the initial construction activities such as removal of topsoil and building berms and access roads. Further, this entire 1,000-acre area would be removed from use for livestock and wildlife for the 25-year operational period. Additionally, the aesthetic impacts of 1,000 acres of lined evaporation ponds would be significant.

Potential impacts to worker safety, which relate to constructing and perpetual operation and maintenance of the focused pumping and evaporation system, consist of an estimated probability of occupational fatality of $8 \times 10^{-2}$ and 89 lost work time injuries over the 25-year design life of the system.

This alternative would require consumption of approximately 1,875 gpm of ground water for 25 years as water is removed from the aquifer and lost to evaporation.

### 3.3.4 Alternative 4 - Perpetual Containment With Institutional Control

The costs associated with this potential alternative are for the construction and operation of a pumping and treatment system that would be operated in perpetuity. The economic costs of this alternative are estimated to be approximately $117 million. The non-economic costs include the potential environmental impacts associated with constructing the wells, the water treatment plant, and for the lined evaporation and sludge disposal ponds. This would involve the initial construction activities such as removal of topsoil and building berms and access roads. Further, approximately 180 acres would be removed from use for livestock and wildlife in perpetuity, and the aesthetic impacts of water treatment plant, the evaporation ponds, and the sludge disposal cells would be significant.

Potential impacts to worker safety consist of an estimated probability of occupational fatality of $1.4 \times 10^{-1}$ and 153 lost work time injuries over the 1,000-year design life of the system. These impacts to worker safety are considered high. This alternative would also cause approximately 1,265 gpm for 25 years and 35 gpm of water in perpetuity as this water would be removed from the aquifer and lost to evaporation.

### 3.4 Corrective Action Benefits

As described above, all four of the alternatives provide the same level of protection to public health and safety and the environment. Concentrations of all COCs will be essentially background at the potential exposure points and, even under worst-case river loading assumptions, will remain protective of public health and safety and the environment. The fundamental difference between the alternatives is that Alternative Nos. 2, 3, and 4 have significant monetary and non-monetary costs and require institutional control over a smaller area than Alternative No. 1. Therefore, the fundamental benefit derived from Alternative Nos. 2 and 3, relative to Alternative No. 1, is maintaining access to ground water for human drinking water supply over incrementally larger areas. In order to determine if the incremental increases in cost (monetary and non-monetary) for the incremental increases in uncontrolled area are justified, some unit value must be developed for areas to which access to ground water for drinking is restricted. This value, on a unit basis, would then be applied to the incremental area over which access to drinking water would be maintained.

Each alternative requires that some land be institutionally controlled in order to provide the required protection of public health and safety and the environment. The institutional controls prevent any future access to impacted ground water for human domestic drinking water. All other uses of the land inside the institutional control area, including the historic use of grazing and wildlife habitat and human habitation, would be acceptable. Therefore, the land inside the institutional control area maintains most of its uses and, thus, a significant portion of its value.

Additionally, there are significant alternate ground water resources in the surrounding area. The Split Rock aquifer in which the site-derived ground water exists is widespread and there are no unique aspects of the ground water within the proposed institutional control areas.

WNI recently has obtained landowner agreement to prohibit future human use or consumption of ground water in one case, and all future ground water uses in another case. These restrictions were obtained for $10/acre and $17/acre, respectively. Based on this, the value of local ground water as a drinking water source ha been estimated to be $15/acre. Therefore, the benefits of Alternatives 2, 3, and 4 are compared to the baseline case, Alternative No. 1, by determining the incremental area over which the ability to use ground water for domestic drinking water would be maintained. The access to ground water for drinking over this incremental land area is then valued at the unit rate of $15/acre.

Since Alternative No. 1 is the baseline alternative, there is no incremental benefit afforded to this alternative. Alternative No. 2 maintains access to ground water for drinking over approximately 2,480 incremental acres more than the baseline alternative. Alternative No. 3 maintains access over approximately 1,457 more acres, and Alternative No. 4 maintains access over approximately 2,310 more acres than the baseline alternative. The total value of each of these incremental areas for Alternative Nos. 2, 3, and 4, respectively, are $37,200, $21,855, and $34,650. The costs and benefits for each of the alternatives are summarized in Table 15.

## 3.5 ALARA Demonstration

As discussed above and detailed in Appendix H, four potential corrective alternatives were developed that all comprise technical components that are best suited for the site specific conditions. All alternatives provide essentially the same level of protection in that COCs at essentially background concentrations exist at the potential exposure points. The alternatives vary in that each has a different area over which institutional control(s) must be provided to prevent the use of ground water for drinking water. The potential alternatives were evaluated using cost-benefit analyses to determine what alternative should be employed based on minimizing the area for institutional control to as small as reasonably achievable. The evaluation compared the costs of minimizing the institutional control area (monetary and non-monetary costs) to the benefit of maintaining the option of using ground water for drinking water. All other traditional land uses remain under all alternatives.

The alternatives vary considerably relative to the individual costs and benefits. Significant costs, which include impacts to the environment, consumptive use of ground water, significant potential worker risks, and large economic costs exist for all alternatives except the baseline alternative (Institutional Control only). The benefits of the three alternatives with higher costs (increased area over which access to ground water for drinking is maintained) are greater than the benefit of the first alternative in that more land maintains the ability to have drinking water wells. However, the benefits of these three alternatives are orders of magnitude less than the costs associated with the alternatives.

# 4.0 PROPOSED ALTERNATIVE

A preferred corrective action alternative has been selected based on the extensive site characterization, predictions of future site conditions and evaluation of a range of potential corrective action alternatives presented in the previous portions of this submittal. This characterization determined that there are no past or current drinking water wells impacted by site-derived constituents. In addition, there are no past, present or potential future public health or environmental hazards associated with site-derived constituents in the Sweetwater River.

The potential that future human pathways of exposure may develop through use of ground water as a long-term drinking water source neccessitates the selection of a corrective action alternative. This alternative must provide a reasonable assurance of protection to public health, safety and the environment and must satisfy the principles underlying ALARA analysis.

Based on the screening of technologies and alternatives described in Chapter 3 of this submittal, the proposed preferred ground water corrective action alternative for the WNI Split Rock Site is the Pathway Elimination Alternative, previously referred to as Alternative No. 1 – Institutional Control with Alternate Water Supply, that incorporates institutional controls and potentially an alternate drinking water supply. This alternative eliminates the potential future human exposure pathway with institutional controls and eliminates access to ground water for human consumption within the proposed long-term care boundary. In addition, it provides for an alternate drinking water supply in the future, should it be required, for existing or future residents within the proposed long-term care boundary who use local ground water for their drinking water supply.

Extensive characterization of the site ground water chemistry and flow systems, with extensive quality control, and modeling of key constituent transport has established the direction and controlling parameters of the ground water flow system. In addition, it has been established that the source of site-derived constituents continues to diminish, and all site-derived constituents in ground water will not migrate beyond the proposed long-term care boundary at concentrations above protective values.

The flux of site-derived constituents from the site is decreasing and will continue to decrease to low levels. Though the concentrations of tailing seepage have been conservatively assumed not to decrease from "worst-case" levels, the seepage rate, which has already decreased from over 1,000 gpm in 1986 to present rates of approximately 150 gpm, is anticipated to decrease to the low, steady-state rate of less than 5 gpm. Net concentrations of site-derived constituents will continue to decrease through time.

All ground water constituent concentrations beyond the proposed long-term care boundary will remain at background levels under all conditions. Furthermore, site-derived constituents will remain within the range of natural background in the river except during possible brief periods of extremely low flow. In the relatively near future, site-derived constituents in the river will not exceed concentrations within the range of natural background concentrations even during the most extreme low flow conditions.

As described in Chapter 3 and Appendix H, peak loading to the Sweetwater River occurred in approximately 1996 and loading is decreasing. Future loading, which could only be detectable during very low flow conditions, would result in concentrations within the range of natural background for all but the most extreme, worst-case low flow conditions. Even under the extreme, worst-case low flow conditions (7 day minimum low flow of 2.1 cfs, see Appendix H) with the entire valley flow at the proposed ACL values, concentrations in the river would remain lower than aquatic protective values for all six site-derived constituents of concern (see Table 16).

Evaluation of the entire aquatic ecosystem during the period of peak loading (1995-1996) indicated that there were no effects to the system from the combined range of site-derived constituents in the river. Further, decreased future loading to the river and the self-flushing nature of the river system assures that there will be no long-term cumulative impacts to the river. Over time the concentration of site-derived constituents in the flood plain will return to protective values for all receptors and concentrations in the river will remain within the range of natural background even during the extreme worst-case low flow events. Therefore, a reasonable assurance of present and future protection to all receptors is provided for the surface water system.

The proposed preferred alternative has no impacts on surface lands, traditional land use, wildlife habitat or on the aesthetics of the area. No changes in ground water use beyond the long-term care boundary will be required. In addition, all traditional land use within the long-term care boundary should be allowed with the exception of use of ground water for domestic drinking water supply. All other alternatives evaluated had significantly greater impacts on surface lands, traditional land use, wildlife habitat, aesthetics of the local area and significantly greater occupational risks to workers. Further, the cost of the proposed preferred alternative is 100 times to 1,000 times less expensive than the other alternatives. As a result, the preferred alternative provides the requisite reasonable assurance of protection and satisfies the principles of the ALARA process.

This alternative has been presented in the previous portion of this submittal in a level of detail sufficient for screening and alternative selection. This chapter provides additional detail regarding the implementation of the alternative. It should be noted that the final proposed area requiring control for the preferred alternative and the operation and maintenance assumptions have been slightly refined from the conditions discussed in Appendix H of this submittal. However, these refinements are minor and do not effect the screening or selection of the preferred alternative.

## 4.1 Alternate Concentration Limits

This section identifies the proposed point of compliance (POC) monitoring wells, the hazardous constituents and the limits for the hazardous constituents at the POC wells. A discussion of the need for compliance monitoring is also provided. Additionally, since site specific conditions are not readily amenable to the establishment of ACLs, an alternative approach, supported by the regulations, is also proposed.

### 4.1.1 Point of Compliance (POC) Wells

The locations of appropriate POC are difficult to establish due to the site specific conditions. The rates of seepage from the tailings have been demonstrated to be decreasing and will continue to decrease over the next several decades. However, tailings seepage is not the only source of hazardous constituents to the ground water system. As established in the site characterization studies (see Appendix F), significant amounts of hazardous constituents from the tailings seepage have become associated with the aquifer solids and will slowly re-mobilize into the ground water over time. The location of at least some of this secondary source term is beyond the edge of the reclaimed tailings.

As stated in 10 CFR Part 40 Appendix A, Criterion 5(B)2, the objective of the POC is to provide "prompt indication of ground-water contamination...". In addition, the introduction to 10 CFR Part 40 Appendix A defines the POC as "the site specific location in the uppermost aquifer where the ground-water compliance standard must be met". In this site specific circumstance, the role of the POC is to provide prompt indication of ground water concentrations that potentially might exceed established levels that could cause non-protective conditions at exposure points. To this end, and because of the secondary source terms noted above, the POC wells for this site under the proposed alternative should be located down gradient of all known source terms and existing peak ground water concentrations. In addition, the POC wells should conservatively evaluate average conditions of the ground water flowing from the site. Since modeling and predicted loading from the source terms to the point of exposure are based on average concentrations and predicted flow rates, compliance monitoring should measure values that represent conditions greater than or, as a minimum, equal to average valley flux conditions. The proposed POC wells were, therefore, selected to monitor conditions that represent conditions greater than or equal to average valley flux conditions. These wells will provide prompt detection of potentially non-protective conditions, should they occur.

The existing POC well for the NW Valley, identified in WNI's Source Material License SUA-56 condition No. 74B as WN-4R, is not down gradient of all the identified source terms or peak ground water concentrations. Well 5 is located down gradient of all known source terms and existing peak ground water concentrations in the NW Valley. Well 5 is screened over a broad portion of the aquifer in the center of the existing and future site constituent flow path. Consequently, this well will monitor conditions representative of the core of the constituent flow from the site which is considerably greater than the average valley concentration. Similarly, WN-21 is down gradient of all source terms and current peak ground water concentrations. Therefore, Well 5 is proposed as the POC in the NW Valley while the existing SW Valley POC well WN-21 remain the POC for this area. These wells will provide ground water quality measurements that are significantly greater than the average concentration of the net ground water flux from the valleys and will provide prompt detection should non-protective conditions occur.

### 4.1.2 Hazardous Constituents and Proposed Standards

A complete characterization of hazardous constituents was conducted and is presented in Appendix I. A list of 25 constituents was originally identified for evaluation (Ag, Al, As, B, Ba, Be, Cd, Co, Cr(total), Cu, F, Hg, Mn, Mo, Ni, $NH_3$, $NO_3$, Pb, Ra-226+228, Sb, Se, Th-230, Tl, U, Zn.). The constituent list includes and exceeds those constituents listed in criterion 13 of 10 CFR Part 40, Appendix A and 40 CFR Part 192. The list of constituents was expanded to include constituents which may impact human health but for which no regulatory requirements are presented in 10 CFR Part 40, Appendix A. It should be noted that no volatile and semi-volatile or organic compounds were identified at the site.

Only 17 constituents (Al, As, Be, Cd, F, Mn, Mo, Ni, $NH_3$, $NO_3$, Pb, Ra-226+228, Sb, Se, Th-230, Tl, and U), referred to as constituents of potential concern (COPC), were identified above background or protective values (MCLs or risk based concentrations ) anywhere on the site including in the tailings. All but six of these 17 constituents will never exceed the higher of background or protective values beyond the POC though they are presently above these standards in the tailings today. Therefore, the proposed license condition standards for these 11 constituents (Al, As, Be, Cd, F, Ni, Pb, Sb, Se, Th-230, and Tl) are the higher of background or protective values (see Table 17). The constituents $NH_3$, $NO_3$, Mn, Mo, Ra-226+228, and U were identified to be above the protective standards today at or down gradient of the POC wells and potentially above protective standards in the future. These hazardous constituents, referred to as constituents of concern (COC) in Appendix I and Appendix H, are the constituents for which alternate concentration limits (ACLs) and alternate standards are proposed.

#### 4.1.2.1 Selection of Alternative Concentration Limits (ACLs)

Typically, ACLs are developed by determining a protective concentration for each hazardous constituent at the point of exposure (POE) for either human or environmental receptors or both. The preferred alternative (Alternative No. 1 Pathway elimination with institutional controls and alternate drinking water supply) will eliminate any possibility for human exposure to by-product materials in ground water. Any potential drinking water well in the area would not have any constituents above background. Additionally, there will not be any environmental receptors for flow from the SW Valley. The only potential receptors from site flow are ecological receptors in the Sweetwater River. As presented in Appendix I the most sensitive of these environmental receptor is the aquatic life in the Sweetwater River.

A comprehensive evaluation of the environmental impact from seepage out the NW Valley was conducted in 1995 (Appendix I). Subsequent analyses indicated that maximum loading to the river occurred around 1995 and was in response to the peak ground water flow rates out the valleys caused by the maximum pool level in the pond which occurred in 1986. Ground water flow rates and concentrations in the upper valleys, and therefore loading to the river, have been demonstrated to be decreasing. In addition, evaluation of the river system indicates there is no potential for cumulative effects. Therefore, as long as the concentrations of the hazardous constituents remain at or below historic levels, all of the environmental receptors will remain protected.

Even if the concentrations could significantly increase over time, the environmental receptors would still remain protected because the loading to the river is a function of the concentrations and the flow rate out the valley. The maximum loading to the river occurred in 1995 which is reflective of both maximum concentrations and maximum flow rates. The maximum ground water flow rate out the NW Valley was approximately 1,200 gpm and the peak tailing seepage rate was 1,000 gpm. Conditions in the Sweetwater River remained protective during these conditions. The current flow rate is approximately 210 gpm (with a current tailings seepage rate of approximately 150 gpm) and the long-term flow rate is expected to be approximately 100 gpm (with a long-term tailings seepage rate of less than 5 gpm). Since the long-term ground water flow rate is approximately 1/10 the maximum historical NW Valley flow rate and tailing long-term tailings seepage rates will be 1/20 of historical peak seepage rates, the long-term concentrations could be 10 to 20 times greater than historic levels and still be protective. This is further shown by modeling presented in Appendix H that within approximately 50 years ground water concentrations of uranium, for instance, will approach background up gradient of the Sweetwater River.

Based on the fact that there are no human receptors and that the environmental receptors will be protected as long as the future concentrations are less than the historic concentrations, ACLs were determined for each of the POC wells based on maximum historic concentrations seen in the valleys. This was done by determining the maximum values for each of the six identified hazardous constituents that have been observed in either the proposed POC wells (Well 5 and well WN-21) or the wells closest to the edge of the tailings (Well 4 and well WN-B). These values are shown on Table 18 and are discussed below for each constituent and for each POC.

**Uranium:**

Northwest Valley:

The historic maximum uranium value for the NW Valley was determined from well WN-4/4R and Well 5. The historic data for both of these wells is presented on Figure 53. As can be seen, the maximum uranium value of 4.8 mg/L from these wells occurred in well in 1991. The most recent uranium values are 0.3 mg/L in well WN-4R and 1.5 mg/L in Well 5. From this, an ACL of 4.8 mg/L is proposed for POC Well 5.

Southwest Valley:

The historic maximum uranium value for the SW Valley was determined from wells WN-B and WN-21. The historic data for both of these wells is presented on Figure 54. As can be seen, the maximum uranium value of 3.4 mg/L in these wells occurred in well WN-B in 1982. The most recent uranium values in well WN-B are 1.9 mg/L and 0.06 mg/L in well 21. From this, an ACL of 3.4 mg/L is proposed for POC well WN-21.

**Radium:**

Northwest Valley:

The historic maximum radium value for the NW Valley was determined from wells WN-4/4R and Well 5. The historic data for both of these wells is presented on Figure 55. As can be seen, the maximum radium value of 7.2 pCi/L from these wells occurred in well WN-4/4R in 1992 and in Well 5 in 1992. The most recent radium values are less than 1.2 pCi/L in both wells. From this, an ACL of 7.2 pCi/L is proposed for POC Well 5.

Southwest Valley:

The historic maximum radium value for the SW Valley was determined from wells WN-B and WN-21. The historic data for both of these wells is presented on Figure 56. As can be seen, the maximum radium value of 19.9 pCi/L from these wells occurred in well WN-B in 1993. The most recent radium values are less than 1.2 pCi/L in both wells. From this, an ACL of 19.9 pCi/L is proposed for POC well WN-21.

**Manganese:**

Northwest Valley:

The historic maximum manganese value for the NW Valley was determined from wells WN-4/4R and Well 5. The historic data for both of these wells is presented on Figure 57. As can be seen, the maximum manganese value of 225 mg/L from these wells occurred in well WN-4/4R in 1983. The most recent manganese values are 79 mg/L in well WN-4R and 0.25 in Well 5. From this, an ACL of 225 is proposed for POC Well 5.

Southwest Valley:

The historic maximum manganese value for the SW Valley was determined from wells B and 21. The historic data for both of these wells is presented on Figure 58. As can be seen, the maximum manganese value of 35 mg/L from these wells occurred in well WN-B in 1982. The most recent manganese values are 1.2 mg/L in well WN-B and

0.14 mg/L in well WN-21. From this, an ACL of 35 mg/L is proposed for POC well WN-21.

**Molybdenum:**

Northwest Valley:

The historic maximum molybdenum value for the NW Valley was determined from wells WN-4/4R and Well 5. The historic data for both of these wells is presented on Figure 59. As can be seen, the maximum molybdenum value 0.66 mg/L from these wells occurred in Well 5 in 1982. The most recent molybdenum values are less than 0.05 mg/L in both wells. From this, an ACL of 0.66 is proposed for POC Well 5.

Southwest Valley:

The historic maximum molybdenum value for the SW Valley was determined from wells WN-B and WN-21. The historic data for both of these wells is presented on Figure 60. As can be seen, the molybdenum has never been identified above detection limits in either well. The maximum value identified during the site characterization is 0.22 mg/L. From this, an ACL of 0.22 mg/L is proposed for POC well WN-21.

**Ammonia:**

Northwest Valley:

The historic maximum ammonia value for the NW Valley was determined from wells WN-4/4R and Well 5. The historic data for both of these wells is presented on Figure 61. As can be seen, the maximum ammonia value of 0.61 mg/L from these wells occurred in well WN-4R in 1996. The most recent ammonia values are 0.1 mg/L in well WN-4R and less than 0.01 mg/L in Well 5. From this, an ACL of 0.61 mg/L is proposed for POC Well 5.

Southwest Valley:

The historic maximum ammonia value for the SW Valley was determined from wells B and 21. The historic data for both of these wells is presented on Figure 62. As can be seen, the maximum ammonia value of 0.84 mg/L from these wells occurred in well WN-B in 1997. The most recent ammonia values are 0.04 in well B and 0.05 mg/L in well WN-21. From this, an ACL of 0.84 is proposed for POC well WN-21.

**Nitrate:**

Northwest Valley:

The historic maximum nitrate value for the NW Valley was determined from wells WN-4/4R and Well 5. The historic data for both of these wells is presented on Figure 63. As can be seen, the maximum nitrate value of 317 mg/L from these wells occurred in well WN-4 in 1982. The most recent nitrate values are 42 mg/L in well WN-4R and 90 mg/L in Well 5. From this, an ACL of 317 mg/L is proposed for POC Well 5.

Southwest Valley:

The historic maximum nitrate value for the SW Valley was determined from wells WN-B and WN-21. The historic data for both of these wells is presented on Figure 64. As can be seen, the maximum nitrate value of 70.7 mg/L from these wells occurred in well WN-B in 1991. The most recent nitrate values are 35 mg/L in well WN-B and 16 mg/L in well WN-21. From this, an ACL of 70.7 mg/L is proposed for POC well WN-21.

As stated previously, virtually any value at the POC wells would ensure protection of human health since there will be no human receptors for any ground water constituent from the tailings impoundment. There are potential environmental receptors for flow out of the NW Valley. An evaluation (Appendix I) demonstrated that the environmental receptors were not adversely impacted during a time that coincided with the maximum ground water flow rates and concentrations out of the NW Valley. Since the flow rates will dramatically decrease and the concentrations of constituents will continue to decrease over time, future loading of by-product material to the river should rapidly cease as shown by the modeling (Appendix H).

However, an independent evaluation using worst-case assumptions was conducted to show that even a very conservative evaluation demonstrated that there will be no future adverse impact to the environmental receptors. This evaluation used the following boundary conditions:

1. Flow in the Sweetwater River was assumed to be at worst-case, low-flow conditions (2.1 cfs). This is approximately 8 times lower than the monthly average low-flow conditions (17 cfs). This conservative assumption adds a large factor of conservatism to the evaluation of protection in the river.
2. Ground water flow rates out the NW Valley remain constant at 1996 levels of 210 gpm. In fact, flow rates out the NW Valley are declining and the estimated current flow rate out the NW Valley is less than 210 gpm. The flow rate is expected to be approximately 100 gpm in the next 30 years.
3. Concentrations of the constituents seeping from the NW Valley are assumed to be constant. As shown in Appendix F, the concentrations are expected to decline over the next several decades.
4. There will be no attenuation of any constituent as the ground water flows from the NW Valley to the river. In fact, testing of constituent migration through un-impacted aquifer materials demonstrates that all of the constituents will have some attenuation with radium, for example, having very high attenuation characteristics and uranium being transported with very little attenuation. The assumption of conservative transport (e.g., no attenuation) is highly conservative, allowing the model to predict significantly greater amounts of constituents above background concentration to reach the river than will actually arrive.

Given these assumptions, the maximum hypothetical worst case concentrations for the 6 constituents were calculated for the Sweetwater River. These concentrations, along with the protective acute aquatic water quality values are presented on Table 16. As can be seen, all constituents, under calculated worst case conditions, are less than the protective values. Therefore, there can be no adverse environmental impact to the Sweetwater River.

### 4.1.3 Compliance Monitoring

No ground water compliance monitoring is warranted for the Split Rock site. As discussed above, the ground water flowing out the SW Valley will not have any human or environmental receptors. While ACLs are proposed for well WN-21, the values could be essentially at any level, and human health and the environment would still be protected.

The potential for long-term impacts to aquatic life from flow from the NW Valley was extensively evaluated. It has been shown that concentrations in the river have not adversely impacted any environmental receptors and the concentrations and flow rates from the NW Valley are continuing to decrease. Further, a worst-case hypothetical evaluation concluded that there is no possibility for any unacceptable impacts to the Sweetwater River. Therefore, there is no need to perform any additional monitoring at well WN-5.

Monitoring at the two proposed POC wells (WN-21 and Well 5) has been performed since 1981. These data clearly show 1) concentrations of virtually all constituents are decreasing and, 2) that these decreasing concentrations are now changing relatively slowly. These wells have successfully measured the stable trend of dissipation and decline of the valley source terms. Therefore, the compliance monitoring history has demonstrated that no additional monitoring should be required to ensure future protection, since protection of public health and the environment has been maintained under historic conditions, and present concentrations have been demonstrated to be decreasing in a stable manner.

In addition to the fact that there are no technical reasons to monitor ground water, there are practical reasons why monitoring is not useful. Ground water flow rates are very slow (15 ft/yr to 25 ft/year – Appendix D) and geochemical conditions are relatively stable, and only expected to lead to decreasing concentrations of all constituents. Long-term historical monitoring of Well 5 and well WN-21 and other wells in the valleys clearly show these trends (see Figures 53 through 64). Significant changes to ground water concentrations would not be seen for decades.

## 4.2 Alternative to ACLs

Inasmuch as site specific conditions do not permit precise adherence to traditional ACL guidance and format, as an alternative to ACLs the Commission may exclude detected constituents from the set of hazardous constituents on a site specific basis, if the Commission finds that the constituents are not capable of posing a substantial present or potential future hazard to public health, safety and the environment. 10 CFR Part 40, Appendix A, Criterion 5B(3) specifically authorizes this approach and sets forth that in deciding whether to exclude constituents, the Commission will consider the following:

**(a)** Potential adverse effects on ground water quality, considering –

- (i) The physical and chemical characteristics of the waste in the licensed site, including its potential for migration;
- (ii) The hydrogeological characteristics of the facility and surrounding land;
- (iii) The quantity of ground water and the direction of ground water flow;
- (iv) The proximity and withdrawl rates of ground water users;
- (v) The current and future uses of ground water in the area;
- (vi) The existing quality of ground water, including other sources of contamination and their cumulative impact on ground water quality;
- (vii) The potential for health risks caused by human exposure to waste

constituents;

(viii) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents;

(ix) The persistence and permanence of the potential adverse effects.

**(b)** Potentially adverse effects on hydraulically-connected surface water quality, considering –

(i) The volume and physical and chemical characteristics of the waste in the licensed site;

(ii) The hydrogeological characteristics of the facility and surrounding land;

(iii) The quantity of ground water and the direction of ground water flow;

(iv) The patterns of rainfall in the region;

(v) The proximity of the license site to surface waters;

(vi) The current and future uses of surface water in the area, and any water quality standards established for those waters;

(vii) The existing quality of surface water, including other sources of contamination and the cumulative impact on surface water quality;

(viii) The potential for health risks caused by human exposure to waste constituents;

(ix) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents;

(x) The persistence and permanence of the potential adverse effects.

All of the above technical considerations have been addressed in this report and appendixes. The specific treatments of all these technical considerations have been discussed in the preceding chapters of this submittal in the attached technical appendixes. They are summarized briefly below.

Regarding Criterion 5B(3)(a)(i), the physical and chemical characteristics of the waste at the Split Rock Site were fully characterized and are described in Section 2 of this submittal and are documented in Appendix F. The procedures and methods used in this characterization are included in Appendix A, Appendix B and Appendix F. This characterization identified the tailings and the aquifer soils, which have become loaded with site constituents, as the long-term sources of constituents to ground water. In Section 3.0 and Appendix I of this submittal, 17 constituents of potential concern (COPC) were identified as existing above the higher of MCLs, background or risk-based concentrations (RBCs) at the site. Of these 17 COPC, only six constituents of concern (COC or hazardous constituents) were identified as presently above the higher of background, MCLs or RBCs down gradient of the reclaimed tailings or potentially above these protective standards in the future. The potential for migration of all 17 COPC was evaluated in Appendix F. The transport of the six COC were conservatively modeled, assuming no retardation to characterize their potential future distribution and loading to the Sweetwater River.

The hydrogeological characteristics of the facility and the surrounding land, identified in Criterion 5B(3)(a)(ii), were extensively characterized using over 123 wells, 102 minipiezometers, extensive aquifer testing, review of historical data, surface geophysical logging, borehole and well geophysical logging, and evaluation of site water balance. The results of these characterization efforts are documented in Appendix A through Appendix E. Similarly, the quantity of ground water and direction of flow, referred to in Criterion 5B(3)(a)(iii), has been extensively evaluated through mapping of hydrologic conditions and using a 3-dimensional finite element computer model (MODFLOW) developed from the characterization of hydrogeological conditions. These results have been discussed in Section 2.0 of this submittal and are documented in detail in Appendix C, Appendix D and Appendix E.

The site characterization described in Section 2.0, identified all registered wells and several un-registered in the site vicinity and their ground water uses. This data, referenced in Criterion 5B(3)(a)(iv) and (v), is also provided in Appendix D of this submittal. Similarly, the current uses of the ground water in the area were determined to include agricultural applications, stock watering, and domestic drinking water use. Future uses were assumed to be the same as current use due to declining populations and industry in the area. This topic was addressed in Section 3.0 and Appendix I and Appendix H of this submittal.

Regarding Criterion 5B(3)(a)(vi), the existing ground water quality was extensively characterized as described in Section 2.0 and Appendix F of this submittal. Existing background ground water quality varies considerably with localized areas of naturally occurring uranium concentrations above RBC levels identified in areas of existing ground water use for domestic drinking water to the east of the site and in areas to the southwest. The existing ground water quality outside the NW and SW Valleys is presently and will remain suitable for all traditional uses (i.e., stock watering, agricultural uses, industrial uses, etc.) with the exception of use as a long-term domestic drinking water supply within the proposed area requiring institutional control. In addition, the present and potential future extent of all site-derived constituents were characterized. These results are described in Section 2.0 of this submittal and documented in detail in Appendix F and Appendix H.

In regard to Criterion 5B(3)(a)(vii) and (viii), there are no present impacts to public health, safety and the environment. No human receptors are presently using the ground water containing site-derived constituents for domestic drinking water supply. In addition, all ecological receptors are and will remain protected even under worst-case hypothetical exposure conditions. The existing and pending institutional controls and alternate drinking water supply will completely eliminate any potential for future human exposure. Therefore, there is no potential for adverse impacts to human health, wildlife, crops, vegetation or physical structures from site constituents. Because there are no adverse effects from site constituents, the issue of the persistence and permanence of adverse effects from waste sources identified in Criterion 5B(3)(a)(ix) does not exist. Only restricted access to ground water for domestic drinking water supply over an area of approximately 5,196 acres will be required. Of this 5,196 acres, control would be required over approximately 1,600 acres irrespective of ground water quality due to surface reclamation issues.

Similarly, the effects on hydraulically-connected surface waters, identified in Criterion 5B(3)(b) have been extensively evaluated and addressed in this submittal. Specifically, items Criterion 5B(3)(b)(i) through (iii) are the same as Criterion 5B(3)(a)(i) through (iii) and are discussed above. Site climate and regional rainfall, identified in item (iv), have been described in Section 2 and Appendix D of this submittal. The site is located in the high arid west with average annual rainfall of less than 11 inches per year and average infiltration rates of less than 2 inches per year. This arid climate reduces the recharge to the hydrologic system and limits the long-term transport of site constituents.

The proximity of the site to surface waters, the current and future uses of these waters and the existing surface water quality, identified in Criterion 5B(3)(a)(v) through (vii), were included in the site characterization described in Section 2.0 of this submittal. The tailings disposal facility is located approximately ½ mile south of the Sweetwater River. The river water is currently used for agricultural watering through surface diversions and supports recreational habitat for fish and other aquatic life, birds and waterfowl, deer and other wildlife. The river is classified as a Class II river by the State of Wyoming and this classification will not change under the proposed alternative. Ecological receptors in the river have been and will remain protected from any adverse impacts, even under hypothetical worst-case conditions. Other sources of constituent loading to the river include loading from agricultural runoff upstream and impacts from livestock. These issues and conditions are described in Sections 2.0 and 3.0 of this submittal as well as in Appendix F and Appendix I.

There is no potential for adverse effects to humans from exposure to site constituents in surface water as surface water is not used for consumptive purposes and any potential acute, short duration exposure, even under worst-case river concentration conditions, would not exceed protective human or aquatic life levels. Similarly, there are and will be no adverse impacts to wildlife, crops, vegetation or physical structures from site constituents in ground water. Consequently, there can be no permanent adverse effects because there are no present or potential future adverse effects. This topic, identified by Criterion 5B(3)(a)(viii) through (x), is discussed in Section 3.0 of this submittal and Appendix I and Appendix H.

The contents of this submittal sufficiently address all of the requisite issues identified by Criterion 5B(3) and Criterion 5B(6) of 10 CFR Part 40, Appendix A. Additionally, they satisfy several of the criteria for applying supplemental standards set forth in 40 CFR Part 192.21 which are applicable to inactive Title II uranium mill tailings sites. Although such criteria are, strictly speaking, not applicable to Title II sites, NRC itself has stated "the use of criteria like the Title I supplemental standards established by EPA" provides an acceptable basis (perhaps in conjunction with other criteria) to make a finding that public health, safety and the environment will be adequately protected (Memorandum from Hugh L. Thompson to Robert D. Martin entitled "Use of Title I Supplemental Standards for Title II sites, July 17, 1988). Some of those Title I criteria that would appear relevant are as follows:

- Avoiding corrective actions that pose a clear risk of injury to workers notwithstanding reasonable measures to avoid or reduce risk;
- Avoiding environmental harm that is clearly excessive and grossly disproportionate in proportion to the environmental benefits reasonably expected;
- Avoiding estimated costs that are unreasonably high relative to the long-term benefits, and the residual radioactive materials pose no clear present or future hazard;
- Remedial action generally will not be necessary where site specific factors limit their hazard potential;
- Practically speaking, there is no known remedial action (if one considers active remediation in perpetuity both impractical and in violation of regulatory references for long-term "passive" controls).

As the ICRP has stated, a fundamental premise of any proposed reclamation/corrective action (i.e., intervention) is that such intervention "should do more good than harm". The form, scale and duration of any such intervention should assure that the *net benefit* be *maximized* (ICRP, 1990). This Plan satisfies this fundamental principle which is essentially as embodied in Criterion 5B(6), 5B(3) and EPA's Supplemental Standards in 40 CFR Part 192.12.

Because of the site specific conditions at the Split Rock Site, constituents are not capable of posing a substantial present or potential future hazard to public health, safety and the environment. There are no human receptors or even a potential pathway due to the implementation of enforceable institutional controls over access to ground water. Therefore, the Commission may exclude the detected constituents as non-hazardous as an alternative to granting ACLs. In addition, due to the site specific conditions, no monitoring of the ground water conditions is necessary as no present or potential future hazard to public health, safety and the environment exists.

## 4.3 Proposed Implementation Measures

### 4.3.1 Institutional Controls

The institutional controls associated with the preferred alternative include:

- Transfer of title for lands owned by Western Nuclear, Inc. (WNI) to the long-term custodian. The long-term custodian, as owner, can restrict and/or prohibit access to ground water.
- Transfer of control and management of lands owned by the United States from the Bureau of Land Management (BLM) to the long-term custodian. The long-term custodian, as representative of the owner, can restrict and/or prohibit access to ground water.

- Enforceable restrictive covenants and/or equitable servitudes[2] on access to or use of ground water under lands owned by third parties within the long-term surveillance area. These equitable servitudes and restrictive covenants will benefit and run with the fee land transferred to the long-term custodian and can be enforced by the custodian as owner of the transferred land.
- Possible restrictions on water use classification by the Office of the Wyoming State Engineer.
- Possible use of deed annotation and notification in local public land records (see Criterion 11C of 10 CFR Part 40, Appendix A).

Figure 65 illustrates the area requiring institutional control over access to ground water for domestic drinking water supply. In addition, this figure illustrates the type of institutional control provided for the lands within the area requiring institutional control.

WNI presently owns 3,652 acres within the proposed area that require controls, or approximately 70 percent of the area. In addition, approximately 700 acres within the proposed control area are owned by the United States and are managed by the Bureau of Land Management (BLM). Further, WNI has acquired deed restrictions prohibiting the use of ground water for drinking water for the majority of the remaining area. These deed restrictions run with the ownership of the land to be conveyed to the long-term custodian and constitute equitable servitudes. These equitable servitudes include restrictions on use of ground water for domestic water consumption for all lands with existing deed restrictions, and restrictions on any use of ground water for selected portions of these lands (see Figure 65). Future annual inspection by the long-term custodian will ensure that no future inappropriate use of ground water on these lands is developed. Therefore, enforceable controls are in place for approximately 97 percent of the proposed control area.

[2] Equitable servitudes are a type of land use restriction that limits future property uses and can have broad applicability and legal enforceability.

WNI is continuing efforts to acquire the other small areas of private lands within the proposed control area or to acquire deed restrictions for ground water use on these lands. This area of land is less than 3 percent of the proposed control area, and is where WNI proposes an alternate drinking water supply if and when necessary, though not for the next 100 to 200 years.

Due to the remote nature of this area and the history of traditional land use, it is highly unlikely that use of ground water for domestic drinking water within this relatively small area will develop in the future. However, via annual inspections by the long-term custodian and comprehensive notice in the public record regarding the ground water issues in the area, this alternative provides for the protection of public health, safety and the environment. Any individual in the future who might potentially attempt to use the ground water from the land within the proposed long-term care boundary for drinking water (e.g., 2 liters/day) could only be exposed to sub-chronic concentrations of site-derived constituents for a very limited period of time (no more than one or two years). Based on that type of assumed sub-chronic exposure, there would be no adverse health impacts to an average individual.

### 4.3.2 Alternate Drinking Water Supply

In order to protect potential new residents from potential risks from site-derived constituents, an alternate drinking water supply will be provided to eliminate the potential exposure pathway if and when it becomes necessary. It should be noted that replacing the existing domestic wells with much deeper wells on their property or providing the residents with water softening devices would be equally effective in removing the potential exposure to site-derived constituents. However, the proposed alternative includes the most comprehensive response to the new contingency by providing an alternate drinking water supply for new residents who are now using ground water for domestic water supply within the control area. The alternate water supply would be installed in the future should site-derived hazardous constituents be identified in a monitoring well directly up gradient of the residential drinking water wells at concentrations above the action levels described in the following section. Figure 66 illustrates all existing drinking water wells within the proposed control area and the location of the proposed monitoring well to be used to identify concentrations of site-derived hazardous constituents above the action levels.

#### 4.3.2.1 Monitoring and Implementation

It is proposed that a new monitoring well, located approximately 750 ft up gradient of the existing domestic wells of the Red Mule Subdivision (see Figure 66), be installed to provide monitoring for potential arrival of site-derived hazardous constituents. This well would be constructed according to appropriate monitoring well standards and would consist of 100 feet of well screen installed from approximately 10 feet above the water table, and would monitor the ground water quality over the upper 70 feet of the local ground water system. This is consistent with the depth interval over which existing domestic wells access the local ground water.

Because of the slow rate of ground water transport (15 ft/yr to 25 ft/yr.), this monitoring well 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 down gradient area where site-derived constituents could potentially reach existing drinking water wells has been identified to have existing anomalous natural ground water concentrations. This makes use of the regional background hazardous constituents 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 well. Should any site-derived constituents be detected in the monitoring well 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 ground water or due to other non-site related changes in ground water quality. If no error 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 ground water 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.

It is proposed that the alternate drinking water supply well be located in NW¼ of the NW¼ of Section 17, T29N, R91W (see Figure 66), land presently owned by WNI. However, it is recognized that a variety of potential locations for the alternate drinking water supply well exist. As assumed in Appendix H, Attachment H.d, the alternate drinking water well will consist of a 20,000 gallon storage tank and a pump house which would contain the pump and a 250-foot-deep, 8-inch-steel well. Electrical power to the system would be supplied via overhead lines. System piping from the alternate water supply well to the residents would be supplied.

The present value of the funds necessary for well installation, operation, periodic maintenance (O&M) and cost of utilities would be added to the prescribed amount of the long term care fund to be paid by the licensee. Final and detailed costs of this alternative will be determined through discussions between WNI and the long-term custodian during development of the Long-Term Surveillance Plan (LTSP).

## 5.0 REFERENCES

American Public Health Association, 1992. *Standard Methods for the Examination of Water and Wastewater, 8th Edition.* Washington, D.C.: American Public Health Association.

American Society for Testing and Materials (ASTM). 1996. *Provisional Standard Guide for Developing Appropriate Statistical Approaches for Ground Water Detection Monitoring Programs.* ASTM, PS64-96, 14p. Philadelphia, Pennsylvania.

Borchert, W.B. 1977. *Preliminary Digital Model of the Arikaree Aquifer in the Sweetwater River Basin, Central Wyoming.* U.S. Geological Survey, Water-Resources Investigations Open-File Report 77-107.

Borchert, W.B. 1987. *Water Table Contours and Depth to Water in the Southeastern Part of the Sweetwater River Basin, Central Wyoming, 1982.* U.S. Geological Survey, Water-Resources Investigations Report 86-4205.

Brock, T.D., M.T. Madigan, J.M. Martinko, and J. Parker. 1994. *Biology of Microorganisms.* 7th ed. Englewood Cliffs, New Jersey: Prentice Hall.

Canonie Environmental. 1989a. *Application for Alternate Concentration Limits, Split Rock Mill Site, Jeffrey City, Wyoming.* Project 88-114. Prepared for Western Nuclear, Inc., Lakewood, Colorado. March 1989.

Canonie Environmental. 1989b. Reclamation Plan -- Revision Number 2, *Uranium Tailings Disposal Area, Split Rock Mill Site, Jeffrey City, Wyoming.* Project 88-194. March 1989.

Canonie Environmental. 1989c. *Ground Water Corrective Action Program, Split Rock Mill, Jeffrey City, Wyoming, August 1989.* Project 88-193-10. Included with transmittal letter to Nuclear Regulatory Commission by Western Nuclear Inc. August 1989.

Canonie Environmental. 1989d. *Supplement 1 to Ground Water Corrective Action Program (August 1989), Split Rock Mill, Jeffrey City, Wyoming.* September Project 88-193-14.

Cohen, A.C., Jr. 1959. "Simplified Estimators for the Normal Distribution when Samples are Single Censored or Truncated." *Technometrics*, vol. 1, pp. 217-237.

D'Appolonia Consulting Engineers, Inc. 1977a. *Report 1-Tailings Management, Engineers Report, Split Rock Mill, Jeffrey City, Wyoming.* Project No. RM77-419. September 1977.

D'Appolonia Consulting Engineers, Inc. 1977b. *Report 3-Environmental Effects of Present & Proposed Tailings Disposal Practices, Split Rock Mill, Jeffrey City, Wyoming.* Project No. RM77-419. October 1977.

D'Appolonia Consulting Engineers, Inc. 1980. *Wyoming Department of Environmental Quality/Land Quality Division Permit Application , Mill Site, Text, Tables and Figures, Split Rock Mill, Jeffrey City, Wyoming, Western Nuclear, Inc., Lakewood, Colorado.* Project No. RM78-678. April 1980.

Denver Equipment Co., 1961.

EarthInfo, Inc. 1996. "NCDC Summary of the Day." Retrieval from CD-ROM.

Fetter, C.W. 1993. *Contaminant Hydrogeology.* New York, New York: MacMillan Publishing Company.

Garbella, Elmer J. ~1967. *"The Split Rock Mill, Western Nuclear, Inc., Jeffrey City, Wyoming."* Bulletin No. M4-B131, Uranium, R.I.P., and Solvent Extraction, 1200 Tons/24 Hrs. Denver Equipment Company, Denver, Colorado.

Gibbons, R.D. 1994. *Statistical Methods for Ground water Monitoring.* New York, New York: Wiley & Sons.

Hapke, H.J. 1987. Toxikologie fur Veterinarmedzinger, 2nd Ed. Enke-Verlag, Stuttgart.

Harshmann, E.N. 1970. "Uranium Ore Rolls in the United States," in *Uranium Exploration Geology,* Proceedings of a Panel on Uranium Exploration Geology, Vienna, Austria, April 1970, International Atomic Energy Agency, pp. 219-232.

Harshman, E.N. 1974. "Distribution of Elements in Some Roll-type Uranium Deposits," in *Formation of Uranium Ore Deposits*, Proceedings of a Symposium on the Formation of Uranium Ore Deposits, International Atomic Energy Agency. Athens, Greece, May 1974. IAEA/SM-183/4. pp. 169-183.

Integrated Risk Information System (IRIS), 1989. Database. U.S. Environmental Protection Agency, Office of Research and Development.

Klingmuller, L.M.L. 1989. "The Green Mountain Uranium District, Central Wyoming: Type Locality of Solution Front Limb Deposits," in *Uranium Resources and Geology of North America,* Proceedings of Technical Meeting, International Atomic Energy Agency, Saskatoon, Canada, September 1987, IAEA-TECDOC-500, pp. 173-190.

Koch, Donald. 1994. *User's Manual for RAND3D.* Engineering Technologies Associates, Inc. Ellicott City, Maryland. 200 pages.

Landa, E. 1980. "Isolation of Uranium Mill Tailings and their Component Radionuclides from the Biosphere - Some Earth Science Perspectives." Geological Survey Circular 814.

Langmuir, D. and A.C. Riese. 1985. "The Thermodynamic Properties of Radium." *Geochimica et Cosmochimica Acta*, Vol. 49: 1593-1601.

Love, J.D. 1961. "Split Rock Formation (Miocene) and Moonstone Formation (Pliocene) in Central Wyoming." U.S. Geological Survey Bulletin 1121-I.

Love, J.D. 1970. "Cenozoic Geology of the Granite Mountains Area, Central Wyoming." Professional Paper 495-C, U.S. Geological Survey.

McDonald, M.G, and A.W. Harbaugh. 1988. "A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model," Chapter A1, in Book 6, *Techniques of Water Resources Investigations of the U.S. Geological Survey.* U.S. Geological Survey, Reston, Virginia.

National Council on Radiation Protection and Measurements (NCRP). 1987. "Recommendations on Limits for Exposure to Ionizing Radiation." NCRP Report No. 91.

Parkhurst, B.R., R.G. Elder, J.S. Meyer, S.A. Sanchez, R.W. Pennaak, and W.T. Waller. 1984. An Environmental Hazard Evaluation of Uranium in a Rock Mountain Stream. Environ. Toxical. Chem. 3: 113-124

Pierce, R.H. and J.M. Weeks. 1993. Nitrate Toxicity to Five Species of Marine Fish. J. World Aquacult. Soc. 24: 104-107

Plafcan, M., C.A. Eddy-Miller, G.F. Ritz, and J. Holland. 1995. *Water Resources of Fremont County, Wyoming.* U.S. Geological Survey, Water Resources Investigations Report 95-4095.

Prickett, T.A., T.G. Naymik, and C.G. Lonnquist. 1981. "A Random-Walk Solute Transport Model for Selected Ground Water Quality Evaluations." *Illinois Water Survey Bulletin 65.* Champaign, Illinois.

Quinn, James E. ~1961. *"Western Nuclear, Inc., Uranium Mill."* Bulletin No. M4-B104, Mills, Uranium. Denver Equipment Company, Denver, Colorado.

Rosner, B. 1983. "On the Detection of Many Outliers". *Technometrics*, vol. 17, pp. 221-227.

Stephens, J.G. 1964. "Geology and Uranium Deposits at Crooks Gap, Fremont County, Wyoming." U.S. Geological Society Bulletin 1147-F.

Suter, G.W. II. And C.L. Tsao. 1996. Toxicological Benchmanrks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Report No. ES/ER/TM-96. Oak Ridge National Laboratory, Oak Ridge, TN.

U.S. Environmental Protection Agency (EPA). 1989a. *Statistical Analysis of Ground-water Monitoring Data at RCRA Facilities*. NTIS PB89-151047.

U.S. Environmental Protection Agency (EPA). 1989b. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation (RAGS)*. EPA 400/89.

U.S. Environmental Protection Agency (EPA). 1992. *Statistical Analysis of Ground-water Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance, July 1992.*

USEPA. 1998. 1998 Update of Ambient Water Quality Criteria for Ammonia. EPA822-R-98-008

U.S. Nuclear Regulatory Commission (NRC). 1980. *Final Environmental Statement Related to Operation of Split Rock Uranium Mill, Western Nuclear, Inc., NUREG-0639, Docket No. 40-1162.* February 1980.

U.S. Nuclear Regulatory Commission (NRC). 1996. *Alternate Concentration Limits for Title II Uranium Mills.* Staff Technical Position. January 1996.

Western Nuclear, Inc. (WNI). 1976. "Spent Acid Analysis," Memorandum from V.A. Shridhar to T.K. Miyoshi, J.P. Lockhart, and R.L. Averill. January 29.

Western Nuclear, Inc. (WNI). 1980. *Revised Renewal Application for SourceMaterials License SUA-56, Split Rock Mill, Docket No. 40-1162.* March 1980.

Western Nuclear, Inc. (WNI). 1981. "SUA-56, Radioactive Materials License, License Condition #73." Letter to Mr. Pete Garcia, NRC from Mr. Grey Bogden, WNI. April 3.

Western Nuclear, Inc. (WNI). 1983. "Construction of an Add-on Sulfuric Acid Regeneration Plant." Memorandum to Mr. D.O. Rausch from Mr. W.L. McFarland, WNI. April 15.

Western Nuclear, Inc. (WNI). 1987. *Split Rock Mill Decommissioning Plan, Source Materials License No. SUA-56, NRC Docket No. 40-1162.* November 1987.

Western Nuclear, Inc. (WNI). 1993. *1993 Ground Water Corrective Action Program Review, Split Rock Mill Site, Jeffrey City, WY.*

Western Nuclear, Inc. (WNI). 1994. *1994 Ground Water Corrective Action Program Review, Split Rock Mill, Jeffrey City, WY.*

Western Nuclear, Inc. (WNI). 1995. *1995 Ground Water Corrective Action Program Review, Split Rock Mill Site, Jeffrey City, WY.*

Western Nuclear, Inc. (WNI). 1997. *1997 Ground Water Corrective Action Program Review, Split Rock Mill Site, Jeffrey City, WY.*

# TABLES

## Table 1 GWPP Structure and Supporting Appendices (Page 1 of 5)

| Topic | Location |
|---|---|
| **Appendix A – Site Investigation Report** | |
| Introduction | A.1.0 |
| Sweetwater River Flow and Elevation Measurements | A.2.0 |
| Sweetwater River and Floodplain Pond Sampling | A.3.0 |
| Shallow Soil Sampling | A.4.0 |
| Surface Geophysical Surveys | A.5.0 |
| Location of Existing Wells | A.6.0 |
| SMI Minipiezometers | A.7.0 |
| Exploration Drilling and Well/Piezometer Installation | A.8.0 |
| Borehole Geophysics | A.9.0 |
| Aquifer Testing | A.10.0 |
| Tracer Test | A.11.0 |
| Aquifer Material Analysis and Testing | A.12.0 |
| Tailing Material Analysis and Testing | A.13.0 |
| Ground Water Sampling and Analysis | A.14.0 |
| Ground Water Level Measurements | A.15.0 |
| Well Abandonment | A.16.0 |
| References | A.17.0 |
| Boring Logs | Attachment A.a |
| Well Construction Logs | Attachment A.b |
| TEM Geophysical Report, Kenco Minerals | Attachment A.c |
| Seismic Reflection and Refraction Survey Report, Geophysical | Attachment A.d |
| Standard Operating Procedures (SOPs) | Attachment A.e |
| Spectral Gamma Geophysical Logs | Attachment A.f |
| Comparison of Field to Laboratory Aqueous Sulfate Measurements | Attachment A.g |
| **Appendix B – Hydrogeological Characterization** | |
| Introduction | B.1.0 |
| Summary of Geological and Hydrogeological Investigations | B.2.0 |
| Summary of Regional Geology | B.3.0 |
| Description of Local Geology | B.4.0 |
| Summary of Regional Hydrogeology | B.5.0 |
| Description of Local Hydrogeology | B.6.0 |
| References | B.7.0 |
| Hydrogeology Task Work Scope | Attachment B.a |
| Hydrogeology Task Work Plan | Attachment B.b |
| Hydrogeology Component Quality Plan | Attachment B.c |

## Table 1 GWPP Structure and Supporting Appendices (Page 2 of 5)

| Topic | Location |
|---|---|
| **Appendix B – Hydrogeological Characterization (continued)** | |
| Stratigraphic Isopach Maps and Structural Contour Maps | Attachment B.d |
| Geologic Cross Sections | Attachment B.e |
| Hydrostratigraphic Cross Sections at Well Nest and Well Pair Locations | Attachment B.f |
| **Appendix C – Aquifer Properties Characterization** | |
| Introduction | C.1.0 |
| Historic Aquifer Testing | C.2.0 |
| Recent Aquifer Testing (1995 to 1997) | C.3.0 |
| Summary of Results | C.4.0 |
| References | C.5.0 |
| Existing Well Pumping Test Data Analyses | Attachment C.a |
| Laboratory Test Results and Analyses | Attachment C.b |
| Slug Testing Procedures and Data Analyses | Attachment C.c |
| CAP Well Pumping Test Data Analyses | Attachment C.d |
| Single-well Pumping Test Data Analyses | Attachment C.e |
| Multiple-well Pumping Test Data Analyses | Attachment C.f |
| Analytical Methods | Attachment C.g |
| Tracer Testing Report | Attachment C.h |
| **Appendix D – Hydrologic Conceptual Model** | |
| Introduction | D.1.0 |
| Physiography, Topography, Geomorphology, and Land Use | D.2.0 |
| Climate | D.3.0 |
| Vegetation | D.4.0 |
| Hydrology | D.5.0 |
| Surface Water System | D.5.1 |
| Ground Water System | D.5.2 |
| Summary of the Site Hydrologic Conceptual Model | D.6.0 |
| References | D.7.0 |
| Interview with Troy Corbett Concerning Irrigation and Farming Practices | Attachment D.a |
| Water Balance Study | Attachment D.b |
| Average Areal Recharge Estimate | Attachment D.c |
| Infiltration Project Report | Attachment D.d |
| HELP Infiltration Analysis | Attachment D.e |
| Trend Analysis of Tailing Pond Seepage Estimates | Attachment D.f |
| Estimation of Long-term Seepage Rates: Main Tailing Impoundment | Attachment D.g |

## Table 1 GWPP Structure and Supporting Appendices (Page 3 of 5)

| Topic | Location |
|---|---|
| **Appendix D – Hydrologic Conceptual Model (continued)** | |
| Townsite Pumping in Jeffrey City, Wyoming, Technical Memo | Attachment D.h |
| Wells Within a 10-Mile Radius of the Site | Attachment D.i |
| **Appendix E – Ground Water Flow Model Report** | |
| Introduction | E.1.0 |
| Review of Split Rock Site Operational History | E.2.0 |
| Conceptual Model | E.3.0 |
| Ground Water Flow Model | E.4.0 |
| Flow Model Verification | E.5.0 |
| Model Sensitivity | E.6.0 |
| Summary and Conclusions | E.7.0 |
| References | E.8.0 |
| Estimation of 1986 Tailing Pond Seepage | Attachment E.a |
| 1977 Water Balance | Attachment E.b |
| Sensitivity Analysis of the Original Flow Model | Attachment E.c |
| **Appendix F – Geochemical Characterization Report** | |
| Introduction | F.1.0 |
| Site History | F.2.0 |
| Development of Geochemical Database | F.3.0 |
| Source Area Characterization | F.4.0 |
| Ground Water Characterization | F.5.0 |
| Aquifer Material Characterization | F.6.0 |
| Shallow Soil Characterization | F.7.0 |
| Surface Water and Sediment Characterization | F.8.0 |
| Geochemical Behavior of Hazardous Constituents | F.9.0 |
| Geochemical Computer Modeling | F.10.0 |
| Site Geochemical Conceptual Model | F.11.0 |
| References | F.12.0 |
| Geochemistry Task Work Scope | Attachment F.a |
| Geochemistry Task Work Plan | Attachment F.b |
| Geochemistry Task Component Quality Plan | Attachment F.c (Volume 4 of 5) |
| Site Environmental Monitoring History | Attachment F.d |
| Tailing Mineralogy Reports from Hazen Research, Inc. | Attachment F.e |
| Evolution of Historical Trends in Ground Water Chemistry | Attachment F.f |
| Stable Isotope Ground Water Chemistry | Attachment F.g |
| SMIstat Fortran Source Code | Attachment F.h |
| Data Sets Used for Background Determinations | Attachment F.i |

## Table 1 GWPP Structure and Supporting Appendices (Page 4 of 5)

| Topic | Location |
|---|---|
| **Appendix F – Geochemical Characterization Report (continued)** | |
| Optical Mineralogy Study of Aquifer Materials | Attachment F.j |
| Supporting Data for Aquifer Solids Characterization | Attachment F.k |
| Selective Chemical Extraction of Aquifer Materials | Attachment F.l |
| Mass Balance of Uranium in Ground Water, Aquifer Solids, and Tailing | Attachment F.m |
| Uranium, Radium, and Thorium Isotopic Evaluation | Attachment F.n |
| **Appendix G – Transport Model Report** | |
| Introduction | G.1.0 |
| Model Approach | G.2.0 |
| Initial Development of Transport Model | G.3.0 |
| Calibration to 1996 Chemical Data | G.4.0 |
| Conclusions | G.5.0 |
| References | G.6.0 |
| **Appendix H – Corrective Action Alternatives** | |
| Introduction | H.1.0 |
| Site Characterization | H.2.0 |
| Source of Site-Derived Constituents | H.2.4 |
| Nature and Extent of Hazardous Constituents | H.2.5 |
| Screening of Process Options | H.3.0 |
| Corrective Action Process Options | H.3.4 |
| Screening of Process Options | H.3.5 |
| Corrective Action Alternatives Development | H.4.0 |
| Detailed Analysis of Alternatives | H.5.0 |
| Comparative Analysis | H.6.0 |
| References | H.7.0 |
| Effectiveness of Sodium Bicarbonate Lixiviant in Leaching Uranium and Other Constituents of Concern from Split Rock Aquifer Materials | Attachment H.a |
| ENSR Evaluation of Technologies for the Surficial Treatment of Ground Water at the Western Nuclear Split Rock Site | Attachment H.b |
| Predictive Transport Modeling | Attachment H.c |
| Cost Analyses | Attachment H.d |
| Impact Evaluation | Attachment H.e |
| Townsite Pumping in Jeffrey City, Wyoming, Technical Memo | Attachment H.f |
| Corrective Action Plan Review Technical Memo | Attachment H.g |

**Table 1 GWPP Structure and Supporting Appendices** (Page 5 of 5)

| Topic | Location |
|---|---|
| **Appendix I – Baseline Risk Assessment** | |
| Introduction | I.1.0 |
| Evaluation of the Potential Ecological Risks/Summary of the Ecological Risk Assessment | I.2.0 |
| Identification of Hazardous Constituents and Protective Standards | I.3.0 |
| Evaluation of the Human Health Risks Associated With Current and Potential Future Exposure | I.4.0 |
| Summary and Conclusions | I.5.0 |
| References | I.6.0 |
| Calculation of Health Effect Levels (HELs) | Attachment I.a |
| Environmental Assessment Split Rock Mill Site, Jeffrey City, Wyoming | Attachment I.b |
| **Appendix J – Quality Assurance/Quality Control** | |
| Outline of QA/QC Program and Component Documents | J.1.0 |
| Assessment of Data Usability | J.2.0 |
| Achievement of DQOs | J.3.0 |
| Documentation of QA/QC | J.4.0 |
| References | J.5.0 |
| Audits, Reports, and Other Documentation | Attachment J.a |
| QA/QC Work Plan | Attachment J.b |
| QC Reviews | Attachment J.c |

## Table 2 Specific Locations of Key Review Topics in the GWPP and Its Appendices (Page 1 of 4)

| GWPP Topic | Location of Supporting Information and Documentation |
|---|---|
| **Hazard Assessment** | |
| **Source and Contaminant Characterization** | |
| • Uranium recovery processes | Section 2.1.1.1<br>Appendix F: Site Geochemical Characterization, Section F.2 |
| • Types and quantities of reagents used in milling | Section 2.1.1.2<br>Appendix F, Section F.2 |
| • Milled ore compositions | Section 2.1.1.3<br>Appendix F, Section F.2 |
| • Historical and current waste management practices | Section 2.1.1.4<br>Appendix F, Section F.2 |
| • Properties of site-derived constituents | Section 2.1.3<br>Appendix F |
| • Spatial distribution of the various site-derived constituents | Sections 2.1.2 and 2.1.3 |
|   • Type and distribution of constituents | Sections 2.1.2 and 2.1.3<br>Appendix F |
|   • Monitoring program used to delineate and characterize constituent distribution | Section 2.1.2.1<br>Appendix A: Site Investigation Report |
|   • Documentation of sampling, analysis, and QA/QC program | Appendix A |
|     • Sampling | Appendix A |
|     • Analysis | Appendix A |
|     • QA/QC | Exhibit B to GWPP: Project Quality Plan<br>Appendix J: Quality Assurance/Quality Control |
| **Hydrogeologic and Transport Assessment** | |
| • Site Hydrogeologic Characterization | Section 2.2 |
|   • Hydrogeologic Units | Appendix B: Site Hydrogeologic Characterization Report |
|   • Representative conceptual ground water flow model | Section 2.2.5<br>Appendix B, Section B.6<br>Appendix D: Hydrologic Conceptual Model |
|   • Surface waters hydraulically connected to ground water | Sections 2.2.3, 2.2.4, 2.2.5.1<br>Appendix D |
|   • Climatic conditions | Section 2.2.1<br>Appendix D, Section D.3 |
|   • Documentation of data used to characterize site hydrology | Appendix A<br>Appendix C: Aquifer Properties Characterization<br>Appendix D<br>Appendix E: Ground Water Flow Model Report<br>Appendix H: Corrective Action Alternatives Evaluation |
|     • Monitoring, SOPs | Appendix A |
|     • Analyses/evaluation | Appendix C<br>Appendix D |

## Table 2 Specific Locations of Key Review Topics in the GWPP and Its Appendices (Page 2 of 4)

| GWPP Topic | Location of Supporting Information and Documentation |
|---|---|
| **Hydrogeologic and Transport Assessment (continued)** | |
| • Surface Water measurements/evaluation | Appendix D |
| • Ground water flow modeling | Appendix E<br>Appendix H, Attachment H.c |
| • Background water quality | Section 2.2.6<br>Appendix F |
| • Map showing locations of monitoring points | Section 2.2.6 |
| • Ground water | Sections 2.2.6.1 and 2.2.6.2<br>Appendix F, Section F.5 |
| • Surface water | Section 2.2.6.3<br>Appendix F, Section F.8 |
| • Shallow floodplain soils | Section 2.2.6.4<br>Appendix F, Section F.7 |
| • Description of monitoring locations and devices | Section 2.2.6 |
| • Ground water | Sections 2.2.6.1 and 2.2.6.2<br>Appendix F, Section F.5<br>Appendix A |
| • Surface water | Section 2.2.6.3<br>Appendix F, Section F.8<br>Appendix D |
| • Shallow floodplain soils | Section 2.2.6.4<br>Appendix F, Section F.7 |
| • Description of waste distribution at the site | Section 2.1.1<br>Appendix F, Section F.2 |
| • Historical changes | Appendix D<br>Appendix E<br>Appendix F |
| • Hydrualics, flows | Appendix D, Attachments D.f and D.g<br>Appendix E |
| • Ground water quality | Appendix F, Attachments F.d and F.f |
| • Analytical background water quality data | Sections 2.2.6.1, 2.2.6.2, 2.2.6.3, 2.2.6.4<br>Appendix F |
| • Ground water | Sections 2.2.6.1 and 2.2.6.2<br>Appendix F, Section F.5 |
| • Surface water | Section 2.2.6.3<br>Appendix F, Section F.8 |
| • Shallow floodplain soils | Section 2.2.6.4<br>Appendix F, Section F.7 |
| • Description and analysis of potential sources of off-site contamination | Section 2.2.7<br>Appendix F, Section F.8.4 |

## Table 2 Specific Locations of Key Review Topics in the GWPP and Its Appendices (Page 3 of 4)

| GWPP Topic | Location of Supporting Information and Documentation |
|---|---|
| **Hydrogeologic and Transport Assessment (continued)** | |
| • Descriptions | Appendix A<br>Appendix F |
| • Sampling, analysis, preservation protocols | Appendix A, Attachment A.e |
| • Quality assurance protocols | Appendix F, Attachments F.b and F.c |
| • Transport Estimate | Section 3.2 |
| • Conservative estimates of constituent transport | Appendix H, Attachment H.c |
| • Estimates of duration of constituent migration | Appendix F, Sections F.4.6, F.5.6, F.6.6, F.8.6, F.9, F.10.4.6<br>Appendix H, Attachment H.c, Supplement H.c.1 |
| • Estimates of temporal and variability in constituent distribution | Appendix H, Attachment H.c |
| **Exposure Assessment** | |
| • Identify maximum permissible protective levels | Section 2.1.3<br>Appendix I: Baseline Risk Assessment |
| • Evaluate human exposure | Section 2.3.3<br>Appendix I |
| • Consider water uses, water use standards | Section 2.3.3 |
| • Evaluate pathways | Section 2.3.3.1<br>Appendix I, Attachment I.a |
| • Water and food ingestion | Section 2.3.3.1<br>Appendix I, Attachment I.a |
| • Evaluate environmental/non-human exposure | Section 2.3.2<br>Appendix I, Attachment I.b |
| • Can populations realistically be exposed | Section 2.3.2 |
| • Demonstrate that proposed action(s) do not pose present or potential future hazard | Section 2.3<br>Appendix H |
| **Corrective Action Assessment** | |
| • Results of Corrective Action Program | Section 3.1<br>Appendix H, Attachment H.g |
| • Feasibility of alternate corrective actions | Section 3.2<br>Appendix H |

## Table 2 Specific Locations of Key Review Topics in the GWPP and Its Appendices (Page 4 of 4)

| GWPP Topic | Location of Supporting Information and Documentation |
|---|---|
| **Corrective Action Assessment (continued)** | |
| • A complete range of reasonable corrective actions have been identified | Section 3.2<br>Appendix H, Sections H.3 and H.4. |
| • Corrective actions are feasible and appropriate | Section 3.2<br>Appendix H, Sections H.3 and H.5 |
| • Corrective actions have been optimized | Section 3.2<br>Appendix H, Section H.5, Attachments H.a and H.b |
| • Corrective action costs | Section 3.3<br>Appendix H |
| • Value of pre-impacted water resources | Section 3.3<br>Appendix H, Section H.5 |
| • Availability of alternate water supply | Section 3.3<br>Appendix H, Attachment H.d |
| • Corrective action benefits | Section 3.4 |
| • Avoidance of health effects | Section 3.3<br>Appendix H, Section H.5 |
| • Other benefits | Section 3.4<br>Appendix H, Sections H.5 and H.6 |
| • As low as reasonably achievable demonstration | Section 3.5<br>Appendix H, Section H.6 |
| **Proposed Corrective Action** | |
| **Proposed Corrective Action** | **Section 4.0** |
| **Proposed Implementation Measures** | **Section 4.3** |

## Table 3 Site Concentrations

| Constituents | Maximum Concentration From Tailing Area (mg/L) | Maximum Concentration Beyond Edge of Tailing Reclamation (mg/L) | Background Concentrations | | Protective Human Standard (mg/L) |
|---|---|---|---|---|---|
| | | | Floodplain Alluvial Aquifer (mg/L) | Split Rock Formation Aquifer (mg/L) | |
| Aluminum | 578 | 2.02 | 0.1 | 0.13 | 37 (RBC)[a] |
| Ammonia | 0.16 | 2.35 | 0.011 | 0.015 | 0.5 (RBC) |
| Antimony | 0.017 | 0.01 | 0.005 | 0.005 | 0.006 (MCL)[b] |
| Arsenic | 2.64 | 0.058 | 0.024 | 0.1 | 0.05 (MCL) |
| Barium | 0.1 | 0.21 | 0.346 | 0.14 | 2.0 (MCL) |
| Beryllium | 0.084 | <0.01[c] | 0.004 | 0.01 | 0.004 (MCL) |
| Boron | 1.36 | 0.98 | 0.093 | 0.182 | 3.3 (RBC) |
| Cadmium | 0.188 | 0.014 | 0.008 | 0.014 | 0.005 (MCL) |
| Chromium | 0.05 | 0.05 | 0.05 | 0.05 | 0.1 (MCL) |
| Cobalt | 0.44 | 0.02 | 0.02 | 0.02 | 2.2 (RBC) |
| Copper | 0.214 | 0.03 | 0.02 | 0.06 | 1.3 (MCL) |
| Fluoride | 21.7 | 1.33 | 1.04 | 0.517 | 4 (MCL) |
| Lead | 0.11 | 0.005 | 0.005 | 0.050 | 0.015 (MCL[d]) |
| Manganese | 126 | 49.1 | 2.39 | 0.53 | 0.73 (RBC) |
| Mercury | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 (MCL) |
| Molybdenum | 0.55 | 0.22 | 0.1 | 0.1 | 0.18 (RBC) |
| Nickel | 2.29 | 0.11 | 0.05 | 0.05 | 0.73 (RBC) |
| Nitrate | 362 | 201 | 0.88 | 3.99 | 10 (MCL) |
| Radium 226 +228 | 2950 pCi/L | 13.5 | 4.7 | 5.3 | 10 pCi/L (MCL) |
| Selenium | 0.119 | 0.061 | 0.005 | 0.011 | 0.05 (MCL) |
| Silver | 0.05 | 0.05 | 0.05 | 0.05 | 0.18 (RBC) |
| Thallium | 0.075 | 0.013 | 0.013 | 0.003 | 0.002 (MCL) |
| Thorium 230 | 732 pCi/L | 5.5 | 5.5 | 1.8 | 15 pCi/L (MCL[e]) |
| Uranium (natural) | 4.055 | 8.7 | 0.044 | 0.13 | 0.11 (RBC) |
| Zinc | 3.99 | 6.07 | 6.07 | 0.075 | 11 (RBC) |

Notes: [a]RBC = risk-based concentration
[b]MCL = maximum concentration limit
[c]Number is highest detection limit (DL), all analyses <DL, all analyses are <DL with almost all DL ≤ protective standard
[d]0.015 mg/L level for lead is technically not an MCL but an EPA Action Level
[e]There is an EPA MCL value of 15 pCi/L for gross alpha; gross alpha would include both $Th^{230}$ and $Ra^{226+228}$. Assuming the limit of 5 pCi for $Ra^{226+228}$ would allow for 10 pCi gross alpha from $Th^{230}$.

# Table 4 Chemicals Used in Ore Processing, Split Rock Mill

| Chemical | Quantity in Process (approx. 1957-1965) | Quantity in Process (approx. 1965-1980) | Discharged to Tailing vs. Recycled | Use/Purpose |
|---|---|---|---|---|
| Sulfuric acid | 60-100 lb/ton of ore | 75-100 lb/ton of ore | To Tailing | Acidify, leach, and oxidize U ore |
| Manganese dioxide | 7-10 lb/ton of ore | 7.5 lb/ton of ore | To Tailing | Oxidize ore to increase U extraction |
| Powdered iron | 3/4 lb/ton of ore | 1/2 lb/ton of ore | To Tailing | Maintain Eh of solution at 430 mV |
| Nitric acid | 14.68 lb/ton | Not used - replaced by sulfuric acid | Recycled | Acidify solution, elute U from resin |
| Sodium nitrate | 60 g/L in solution | Not used - replaced by sulfuric acid | Recycled | Elute U from resin |
| Sodium chlorate | 1.18 lb/ton | Assumed still about 1 lb/ton | To Tailing | Added beginning in 1960s to oxidize U ore |
| Sodium chloride (salt) | NS | NS | NS | Used in sulfuric acid plant (after 1962) |
| Kerosene | Not used | NS | Recycled | Organic carrier in U solvent extraction |
| Tertiary amine | Not used | 6% in kerosene | Recycled | Elute U from resin by ion-exchange |
| Isodecanol | Not used | 3-4% in kerosene | Recycled | Emulsion control in organic solvent |
| Calcium oxide (lime) | 10.61 lb/ton | Assumed still about 10 lb/ton | To Tailing | Neutralize acid, precipitate gypsum from U-bearing solution |
| Calcium hydroxide | 10% slurry | NS | To Tailing | Neutralize acid, precipitate gypsum from U-bearing solution |
| Sodium carbonate | Not used | NS | To Tailing | Strip molybdenum from U-bearing solution |
| Sodium hydroxide | 0.42 lb/ton | NS | NS | NS |
| Ammonium sulfate | Not used | 120 g/L | Recycled | Used in ion-exchange circuit to strip U from organic carrier |
| Ammonium nitrate | 2.79 lb/ton | NS | NS | NS |
| Anhydrous ammonia | 0.91 lb/ton | Assumed still about 1 lb/ton | To Tailing, some reclaimed as ammonium sulfate | Raise pH and precipitate U from solution |
| Glue (composition not stated) | 0.09 lb/ton | Approximately 0.1 lb/ton, assumed unchanged | NS | NS |
| Polymer (ion exchange resin) | NS | NS | Recycled | Remove U from initial leaching solution |

Sources: Quinn, James E. ~1961. *"Western Nuclear, Inc., Uranium Mill."* Bulletin No. M4-B104, Mills, Uranium. Denver Equipment Company, Denver, Colorado.
Garbella, Elmer J. ~1967. *"The Split Rock Mill, Western Nuclear, Inc., Jeffrey City, Wyoming."* Bulletin No. M4-B131, Uranium, R.I.P., and Solvent Extraction, 1200 Tons/24 Hrs. Denver Equipment Company, Denver, Colorado.
Western Nuclear, Inc. (WNI). 1961. WNI Memo, *"Reagent Usage and Cost for November, 1961,"* dated Dec. 6, 1961.
Western Nuclear, Inc. (WNI). 1963. WNI Memo, *"Quarterly Review of Justification of Maximum Quantities of Reagents Stored in Reagent Warehouse,"* dated May 14, 1963.

Notes: NS = Not stated.

## Table 5 Estimated Monthly Consumption of Chemicals and Reagents, Split Rock Mill

| Substance | Average Consumption (lbs)[a] | Average Consumption (kg) |
|---|---|---|
| Anhydrous ammonia | 510,900 | 1,124,000 |
| Amine (alamine) | 1,350 | 2,970 |
| Hydrated lime[b] | NA[c] | NA |
| Celatom | 51,900 | 114,000 |
| Sulfuric acid | 2,727,000 | 5,999,000 |
| Isodecanol | 1,005 | 2,210 |
| Kerosene | 2,910 | 6,410 |
| Sodium chlorate | 131,000 | 288,200 |
| Sodium carbonate | 135,400 | 297,800 |
| RIP Resin | 195 cubic feet (5.5 cubic meters) | 5.5 cubic meters (195 cubic feet) |
| Salt | 5,520 | 12,100 |
| Caustic soda | 3,500 | 7,700 |

Source: Western Nuclear, Inc. (WNI). 1987. Letter from WNI to NRC, Table 1, dated July 15, 1987.

Notes: [a]Averages are based on five randomly selected months from January 1978 through May 1980.
[b]Occasionally used in conjunction with ammonia for neutralization. Not used since 1972.
[c]NA = not applicable.

## Table 6 Common Reagents Used in Uranium Analyses

| |
|---|
| Tributyl phosphate |
| Dibenzyl methane |
| Pyridine |
| Nitric acid |
| Perchloric acid |
| Sulfuric acid |
| Aluminum nitrate |
| Ethyl acetate |

Sources: Garling, R. 1996. Energy Laboratories, Inc., Casper, Wyoming, personal communication.
Krieger, H.L. and E.L. Whittaker. 1980. *Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, U.S. EPA, EPA-600/4-80-032, August 1980.

## Table 7 Uranium Minerals Identified in the Crooks Gap District

| Mineral Name | Chemical Formula |
|---|---|
| **Oxides:** | |
| Becquerelite | $7\ UO_3 \cdot 11\ H_20$ |
| Uraninite* | $UO_2$ |
| **Phosphates:** | |
| Autunite | $Ca(UO_2)(PO_4)_2 \cdot 10\text{-}12\ H_2O$ |
| Meta-Autunite | $Ca(UO_2)_2(PO_4)_2 \cdot 2\ 1/2\text{-}6\ 1/2\ H_2O$ |
| Phosphuranylite | $Ca(UO_2)_4(PO_4)_2(OH)_4 \cdot 7\ H_2O$ |
| **Silicates:** | |
| Coffinite* | $U(SiO_4)_{1-x}(OH)_{4x}$ |
| Uranophane | $Ca(UO_2)_2(SiO_3)_2(OH)_2 \cdot 5\ H_2O$ |
| Unidentified uranium silicate | |
| **Sulfates:** | |
| Schroeckingerite | $NaCa_3(UO_2)(CO_3)_3(SO_4)F \cdot 10\ H_2O$ |
| Uranopilite | $(UO_2)_6(SO_4)(OH)_{10} \cdot 12\ H_2O$ |
| **Vanadates:** | |
| Metatyuyamunite | $Ca(UO_2)(VO_4)_2 \cdot 5\text{-}7\ H_2O$ |

Source: Stephens, J.G. 1964. *Geology and Uranium Deposits at Crooks Gap, Fremont County, Wyoming,* U.S. Geological Survey 1147-F, U.S. Government Printing Office, Washington, D.C. Table 5, p. F44.

Note: *Principal uranium ores.

## Table 8 Uranium Minerals Identified in the Gas Hills District

| Mineral Name | Chemical Formula |
|---|---|
| **Oxides:** | |
| Uraninite* | $UO_2$ |
| **Phosphates:** | |
| Meta-autunite | $Ca(UO_2)_2(PO_4)_2 \cdot 2\ 1/2\text{-}6\ 1/2\ H_2O$ |
| Phosphuranylite | $Ca(UO_2)_4(PO_4)_2(OH)_4 \cdot 7\ H_2O$ |
| **Silicates:** | |
| Coffinite* | $U(SiO_4)_{1-x}(OH)_{4x}$ |
| Uranophane | $Ca(UO_2)_2(SiO_3)_2(OH)_2 \cdot 5\ H_2O$ |

Source: Stephens, J.G. 1964. *Geology and Uranium Deposits at Crooks Gap, Fremont County, Wyoming,* U.S. Geological Survey Bulletin 1147-F, U.S. Government Printing Office, Washington, D.C. Table 6, p. F52.

Note: *Principal uranium ores.

## Table 9 Areas and Well Locations for COPC[1] Identification

| | | | | | |
|---|---|---|---|---|---|
| **Tailing and Source Area Wells** | | | | | |
| P-1 | SP7-2 | Well-4E | WN-32C | WN-33D | WN-37E |
| SP12-1 | SP7-3 | Well-4R | WN-33A | WN-34 | WN-B |
| SP12-2 | TEB-1 | WN-32A | WN-33B | WN-35A | WELL-28 |
| SP7-1 | TEB-3 | WN-32B | WN-33C | WN-35B | |
| **Split Rock Formation Aquifer Wells (Outside Edge of Tailing Surface Reclamation Area)** | | | | | |
| MP-59 | WN-21 | SWEB-3 | WN-40A | SWAB-18 | SWAB-35 |
| MP-60 | WN-24 | SWEB-4 | WN-40B | SWAB-19 | SWAB-36 |
| MP-61 | WN-25 | SWEB-5 | WN-41A | SWAB-20 | SWEB-10 |
| MP-62 | WN-26 | SWEB-6 | WN-41B | SWAB-21 | SWEB-11 |
| GM-2 | JC-HYD | SWEB-7 | WN-42A | SWAB-22 | SWEB-12 |
| JC-1 | KNIGHT | SWEB-8 | WN-42B | SWAB-23 | SWEB-13 |
| KK-1 | SWAB-1 | SWEB-9 | WN-43A | SWAB-24 | SWEB-14 |
| RM-1 | SWAB-2 | WELL-1 | WN-43B | SWAB-25 | SWEB-1P |
| WM-1 | SWAB-3 | WELL-2 | JOHNSON | SWAB-26 | SWEB-1R |
| WN-A | SWAB-4 | WELL-3 | SWAB-10 | SWAB-27 | WELL-27 |
| WN-C | SWAB-5 | WELL-5 | SWAB-11 | SWAB-28 | WELL-30 |
| COX-1 | SWAB-6 | WN-36A | SWAB-12 | SWAB-29 | WELL-31 |
| COX-2 | SWAB-7 | WN-36B | SWAB-13 | SWAB-30 | WELL-5E |
| FOX-1 | SWAB-8 | WN-36C | SWAB-14 | SWAB-31 | DURBEN-1 |
| SWICK | SWAB-9 | WN-38B | SWAB-15 | SWAB-32 | ANDERSON-1 |
| WN-15 | SWEB-1 | WN-39A | SWAB-16 | SWAB-33 | |
| WN-16 | SWEB-2 | WN-39B | SWAB-17 | SWAB-34 | |
| **Floodplain Alluvial Aquifer Wells** | | | | | |
| JAMERMAN-1 | MP-26 | MP-38W2 | MP-42E1 | MP-51 | MP-69 |
| JJ-1R | MP-26R | MP-39 | MP-42E2 | MP-52 | MP-69X |
| MP-1 | MP-27 | MP-39E1 | MP-42N1 | MP-53 | MP-7 |
| MP-10 | MP-28 | MP-39E2 | MP-42N2 | MP-54 | MP-70 |
| MP-11 | MP-29 | MP-39S1 | MP-43 | MP-55 | MP-8 |
| MP-12 | MP-3 | MP-39S2 | MP-43E1 | MP-56 | MP-9 |
| MP-13 | MP-30 | MP-4 | MP-43E2 | MP-57 | MP-99 |
| MP-14 | MP-31 | MP-40 | MP-43N1 | MP-58 | WN-17 |
| MP-15 | MP-32 | MP-40N1 | MP-43N2 | MP-6 | WN-18 |
| MP-16 | MP-33 | MP-40N2 | MP-44 | MP-63 | WN-19 |
| MP-17 | MP-34 | MP-40W1 | MP-45 | MP-64 | WN-23 |
| MP-18 | MP-35 | MP-40W2 | MP-46 | MP-65 | WN-38C |
| MP-2 | MP-36 | MP-41 | MP-47 | MP-65A | WN-39C |
| MP-22 | MP-37 | MP-41E1 | MP-47R | MP-66 | WN-40C |
| MP-23 | MP-38 | MP-41E2 | MP-48 | MP-67 | WN-41C |
| MP-23R | MP-38S1 | MP-41N1 | MP-49 | MP-66 | WN-42C |
| MP-24 | MP-38S2 | MP-41N2 | MP-5 | MP-67 | WN-43C |
| MP-25 | MP-38W1 | MP-42 | MP-50 | MP-68 | |

Notes: [1]COPC = Constituents of Potential Concern

## Table 10 Sweetwater River Historical Flow Data

| | Sweetwater Station[1] | | | Alcova[2] | | |
|---|---|---|---|---|---|---|
| **Month** | **Min (cfs)** | **Max (cfs)** | **Mean (cfs)** | **Min (cfs)** | **Max (cfs)** | **Mean (cfs)** |
| **January** | 17 | 38 | 27 | 39 | 39 | 39 |
| **February** | 29 | 40 | 35 | 39 | 39 | 39 |
| **March** | 34 | 236 | 73 | 80 | 80 | 80 |
| **April** | 136 | 2430 | 612 | 191 | 795 | 390 |
| **May** | 450 | 1040 | 693 | 360 | 830 | 542 |
| **June** | 165 | 840 | 468 | 140 | 790 | 398 |
| **July** | 42 | 163 | 94 | 38 | 136 | 64 |
| **August** | 21 | 52 | 36 | 25 | 57 | 38 |
| **September** | 19 | 25 | 22 | 12 | 39 | 23 |
| **October** | 42 | 86 | 63 | 54 | 62 | 55 |
| **November** | 35 | 85 | 56 | 52 | 54 | 54 |
| **December** | 25 | 42 | 36 | 45 | 45 | 45 |
| **Overall** | 17 | 2430 | 185 | 12 | 830 | 147 |

Notes: [1]Sweetwater River at Sweetwater Station (Period of Record: 10/1/73-10/6/92) located approximately 19 miles west (upstream) of the site.
[2]Sweetwater River Near Alcova, Wyoming (Period of Record: 10/01/13-09/30/97) located approximately 40 miles east (downstream) of the site.

## Table 11 Background Ground Water Sampling Locations

| Split Rock Formation | Floodplain Alluvium |
|---|---|
| SAB-1 | JJ-1R |
| SAB-2 | MP-11 |
| SAB-3 | MP-26 |
| SAB-4 | MP-26R |
| SAB-5 | MP-27 |
| SAB-6 | MP-36 |
| SAB-7 | MP-50 |
| SAB-8 | MP-51 |
| SEB-1 | MP-52 |
| SWAB-22 | MP-53 |
| SWAB-23 | MP-54 |
| SWAB-26 | MP-55 |
| SWAB-27 | MP-56 |
| SWAB-32 | MP-57 |
| Anderson-1 | MP-66 |
| Durben-1 | MP-67 |
| Knight | MP-68 |
| Swick | MP-69 |
| Well #22 | MP-70 |
| Well #27 | WN-43C |
| WN-43A | |
| WN-43B | |

## Table 12 Background Upper Prediction Limits for Split Rock Formation Ground Water (Page 1 of 2)

| Analyte | Distribution | Records | Percent Non-det. | UPL Type | UPL_K=1 | %Conf. | Resamples | UPL_k=5 | % Conf. | Resamples | UPL_k=10 | % Conf. | Resamples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ag (mg/L) | 0 | 72 | 100.0 | 2 | 0.050 | 99 | 0 | 0.050 | 94 | 1 | 0.050 | 88 | 1 |
| Al (mg/L) | 0 | 92 | 98.9 | 2 | 0.130 | 99 | 0 | 0.130 | 95 | 0 | 0.130 | 90 | 1 |
| Alkalinity as $CaCO_3$ (mg/L) | 4 | 81 | 0.0 | 2 | 297.0 | 99 | 0 | 297.0 | 94 | 1 | 297.0 | 89 | 1 |
| As (mg/L) | 4 | 103 | 41.7 | 2 | 0.100 | 99 | 0 | 0.100 | 95 | 0 | 0.100 | 91 | 1 |
| B (mg/L) | 3 | 73 | 19.2 | 4 | 0.182 | 95 | 0 | 0.365 | 95 | 0 | 0.476 | 95 | 0 |
| Ba (mg/L) | 0 | 95 | 84.2 | 2 | 0.140 | 99 | 0 | 0.140 | 95 | 0 | 0.140 | 90 | 1 |
| Be (mg/L) | 0 | 72 | 100.0 | 2 | 0.010 | 99 | 0 | 0.010 | 94 | 1 | 0.010 | 88 | 1 |
| Ca (mg/L) | 4 | 111 | 0.0 | 2 | 141.0 | 99 | 0 | 141.0 | 96 | 0 | 141.0 | 92 | 1 |
| Cd (mg/L) | 0 | 96 | 94.8 | 2 | 0.014 | 99 | 0 | 0.014 | 95 | 0 | 0.014 | 91 | 1 |
| Cl (mg/L) | 4 | 115 | 1.7 | 2 | 216.0 | 99 | 0 | 216.0 | 96 | 0 | 216.0 | 92 | 1 |
| Co (mg/L) | 0 | 32 | 100.0 | 2 | 0.020 | 97 | 0 | 0.020 | 86 | 1 | 0.020 | 76 | 1 |
| Conductivity, field (µS/cm) | 4 | 109 | 0.0 | 2 | 1358.0 | 99 | 0 | 1358.0 | 96 | 0 | 1358.0 | 92 | 1 |
| Cr (mg/L) | 0 | 95 | 95.8 | 2 | 0.050 | 99 | 0 | 0.050 | 95 | 0 | 0.050 | 90 | 1 |
| Cu (mg/L) | 0 | 77 | 87.0 | 2 | 0.060 | 99 | 0 | 0.060 | 94 | 1 | 0.060 | 89 | 1 |
| Fluoride (mg/L) | 3 | 31 | 0.0 | 4 | 0.517 | 95 | 0 | 0.635 | 95 | 0 | 0.687 | 95 | 0 |
| Fe (mg/L) | 0 | 97 | 77.3 | 2 | 0.400 | 99 | 0 | 0.400 | 95 | 0 | 0.400 | 91 | 1 |
| Hg (mg/L) | 0 | 91 | 98.9 | 2 | 0.001 | 99 | 0 | 0.001 | 95 | 0 | 0.001 | 90 | 1 |
| K (mg/L) | 4 | 111 | 0.0 | 2 | 12.2 | 99 | 0 | 12.2 | 96 | 0 | 12.2 | 92 | 1 |
| Mg (mg/L) | 4 | 111 | 0.0 | 2 | 45.1 | 99 | 0 | 45.1 | 96 | 0 | 45.1 | 92 | 1 |
| Mn (mg/L) | 0 | 97 | 59.8 | 2 | 0.530 | 99 | 0 | 0.530 | 95 | 0 | 0.530 | 91 | 1 |
| Mo (mg/L) | 0 | 95 | 100.0 | 2 | 0.100 | 99 | 0 | 0.100 | 95 | 0 | 0.100 | 90 | 1 |
| Na (mg/L) | 4 | 111 | 0.0 | 2 | 88.9 | 99 | 0 | 88.9 | 96 | 0 | 88.9 | 92 | 1 |
| $NH_4$-N (mg/L) | 0 | 105 | 81.0 | 2 | 0.700 | 99 | 0 | 0.700 | 95 | 0 | 0.700 | 91 | 1 |
| Ni (mg/L) | 0 | 96 | 100.0 | 2 | 0.050 | 99 | 0 | 0.050 | 95 | 0 | 0.050 | 91 | 1 |
| $NO_2$+$NO_3$-N (mg/L) | 4 | 62 | 12.9 | 2 | 3.99 | 98 | 0 | 3.99 | 93 | 1 | 3.99 | 86 | 1 |
| $NO_2$-N (mg/L) | 4 | 25 | 24.0 | 2 | 5.00 | 96 | 0 | 5.00 | 83 | 1 | 5.00 | 71 | 1 |
| $NO_3$-N (mg/L) | 4 | 53 | 3.8 | 2 | 2.33 | 98 | 0 | 2.33 | 91 | 1 | 2.33 | 84 | 1 |

## Table 12 Background Upper Prediction Limits for Split Rock Formation Ground Water (Page 2 of 2)

| Analyte | Distribution | Records | Percent Non-det. | UPL Type | UPL_K=1 | %Conf. | Resamples | UPL_k=5 | % Conf. | Resamples | UPL_k=10 | % Conf. | Resamples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P (mg/L) | 0 | 53 | 77.4 | 2 | 0.120 | 98 | 0 | 0.120 | 91 | 1 | 0.120 | 84 | 1 |
| Pb (mg/L) | 0 | 104 | 100.0 | 2 | 0.050 | 99 | 0 | 0.050 | 95 | 0 | 0.050 | 91 | 1 |
| Pb210 (pCi/L) | 3 | 25 | 0.0 | 4 | 1.74 | 95 | 0 | 2.10 | 95 | 0 | 2.26 | 95 | 0 |
| pH (field values) | 1 | 111 | 0.0 | 3 | 8.27 | 95 | 0 | 8.44 | 95 | 0 | 8.54 | 95 | 0 |
| pH (field values - LPLs) | 1 | 111 | 0.0 | 3 | 7.01 | 95 | 0 | 6.83 | 95 | 0 | 6.73 | 95 | 0 |
| Po210 (pCi/L) | 4 | 25 | 0.0 | 2 | 2.10 | 96 | 0 | 2.10 | 83 | 1 | 2.10 | 71 | 1 |
| Ra-Combined (pCi/L) | 0 | 15 | 73.3 | 2 | 5.30 | 94 | 1 | 5.30 | 75 | 1 | 5.30 | 60 | 2 |
| Ra226 (pCi/L) | 0 | 85 | 62.4 | 2 | 2.0 | 99 | 0 | 2.0 | 94 | 1 | 2.0 | 89 | 1 |
| Ra228 (pCi/L) | 0 | 60 | 88.3 | 2 | 4.7 | 98 | 0 | 4.7 | 92 | 1 | 4.7 | 86 | 1 |
| Sb (mg/L) | 0 | 52 | 94.2 | 2 | 0.005 | 98 | 0 | 0.005 | 91 | 1 | 0.005 | 84 | 1 |
| Se (mg/L) | 0 | 95 | 77.9 | 2 | 0.011 | 99 | 0 | 0.011 | 95 | 0 | 0.011 | 90 | 1 |
| Silica (mg/L) | 4 | 62 | 0.0 | 2 | 60.5 | 98 | 0 | 60.5 | 93 | 1 | 60.5 | 86 | 1 |
| Sulfate (mg/L) | 4 | 124 | 0.0 | 2 | 133.0 | 99 | 0 | 133.0 | 96 | 0 | 133.0 | 93 | 0 |
| Sr (mg/L) | 3 | 51 | 0.0 | 4 | 1.15 | 95 | 0 | 1.64 | 95 | 0 | 1.88 | 95 | 0 |
| TDS (mg/L) | 4 | 123 | 0.0 | 2 | 900.0 | 99 | 0 | 900.0 | 96 | 0 | 900.0 | 92 | 0 |
| Th230 (pCi/L) | 0 | 85 | 61.2 | 2 | 1.8 | 99 | 0 | 1.8 | 94 | 1 | 1.8 | 89 | 1 |
| Tl (mg/L) | 0 | 52 | 100.0 | 2 | 0.003 | 98 | 0 | 0.003 | 91 | 1 | 0.003 | 84 | 1 |
| U (mg/L) | 4 | 102 | 2.0 | 2 | 0.1264 | 99 | 0 | 0.1264 | 95 | 0 | 0.1264 | 91 | 1 |
| V (mg/L) | 0 | 75 | 98.7 | 2 | 0.100 | 99 | 0 | 0.100 | 94 | 1 | 0.100 | 88 | 1 |
| Zn (mg/L) | 0 | 77 | 71.4 | 2 | 0.075 | 99 | 0 | 0.075 | 94 | 1 | 0.075 | 89 | 1 |

Note: See Table F-5-21 (Appendix F) for a description of abbreviations and codes used in this table.

**Table 13 Background Upper Prediction Limits for Floodplain Alluvium Ground Water** (Page 1 of 2)

| Analyte | Distribution | Records | Percent Non-det. | UPL Type | UPL_K=1 | %Conf. | Resamples | UPL_k=5 | % Conf. | Resamples | UPL_k=10 | %Conf. | Resamples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ag (mg/L) | 0 | 22 | 100 | 2 | 0.050 | 96 | 0 | 0.050 | 81 | 1 | 0.050 | 69 | 1 |
| Al (mg/L) | 0 | 22 | 100 | 2 | 0.100 | 96 | 0 | 0.100 | 81 | 1 | 0.100 | 69 | 1 |
| Alkalinity as $CaCO_3$ (mg/L) | 4 | 38 | 0 | 2 | 370 | 97 | 0 | 370 | 88 | 1 | 370 | 79 | 1 |
| As (mg/L) | 3 | 22 | 0 | 4 | 0.024 | 95 | 0 | 0.037 | 95 | 0 | 0.043 | 95 | 0 |
| B (mg/L) | 3 | 22 | 0 | 4 | 0.093 | 95 | 0 | 0.131 | 95 | 0 | 0.150 | 95 | 0 |
| Ba (mg/L) | 3 | 22 | 50 | 4 | 0.346 | 95 | 0 | 0.484 | 95 | 0 | 0.553 | 95 | 0 |
| Be (mg/L) | 0 | 22 | 100 | 2 | 0.004 | 96 | 0 | 0.004 | 81 | 1 | 0.004 | 69 | 1 |
| Ca (mg/L) | 4 | 38 | 0 | 2 | 91.70 | 97 | 0 | 91.70 | 88 | 1 | 91.70 | 79 | 1 |
| Cd (mg/L) | 0 | 22 | 90.9 | 2 | 0.008 | 96 | 0 | 0.008 | 81 | 1 | 0.008 | 69 | 1 |
| Cl (mg/L) | 4 | 38 | 0 | 2 | 21.0 | 97 | 0 | 21.0 | 88 | 1 | 21.0 | 79 | 1 |
| Co (mg/L) | 0 | 22 | 100 | 2 | 0.020 | 96 | 0 | 0.020 | 81 | 1 | 0.020 | 69 | 1 |
| Conductivity, field (µS/cm) | 4 | 38 | 0 | 2 | 774 | 97 | 0 | 774 | 88 | 1 | 774 | 79 | 1 |
| Cr (mg/L) | 0 | 22 | 100 | 2 | 0.050 | 96 | 0 | 0.050 | 81 | 1 | 0.050 | 69 | 1 |
| Cu (mg/L) | 0 | 22 | 95.5 | 2 | 0.020 | 96 | 0 | 0.020 | 81 | 1 | 0.020 | 69 | 1 |
| Fluoride (mg/L) | 3 | 23 | 0 | 4 | 1.04 | 95 | 0 | 1.45 | 95 | 0 | 1.66 | 95 | 0 |
| Fe (mg/L) | 4 | 22 | 50 | 2 | 4.30 | 96 | 0 | 4.30 | 81 | 1 | 4.30 | 69 | 1 |
| Hg (mg/L) | 0 | 22 | 100 | 2 | 0.001 | 96 | 0 | 0.001 | 81 | 1 | 0.001 | 69 | 1 |
| K (mg/L) | 4 | 38 | 0 | 2 | 15.5 | 97 | 0 | 15.5 | 88 | 1 | 15.5 | 79 | 1 |
| Mg (mg/L) | 4 | 38 | 0 | 2 | 25.2 | 97 | 0 | 25.2 | 88 | 1 | 25.2 | 79 | 1 |
| Mn (mg/L) | 3 | 22 | 22.7 | 2 | 2.39 | 96 | 0 | 2.39 | 81 | 1 | 2.39 | 69 | 1 |
| Mo (mg/L) | 0 | 22 | 100 | 2 | 0.100 | 96 | 0 | 0.100 | 81 | 1 | 0.100 | 69 | 1 |
| Na (mg/L) | 4 | 38 | 0 | 2 | 91.6 | 97 | 0 | 91.6 | 88 | 1 | 91.6 | 79 | 1 |
| $NH_4$-N (mg/L) | 0 | 22 | 63.6 | 2 | 0.160 | 96 | 0 | 0.160 | 81 | 1 | 0.160 | 69 | 1 |
| Ni (mg/L) | 0 | 22 | 100 | 2 | 0.050 | 96 | 0 | 0.050 | 81 | 1 | 0.050 | 69 | 1 |
| $NO_2$+$NO_3$-N (mg/L) | 0 | 22 | 72.7 | 2 | 0.880 | 96 | 0 | 0.880 | 81 | 1 | 0.880 | 69 | 1 |
| P (mg/L) | 0 | 22 | 90.9 | 2 | 0.200 | 96 | 0 | 0.200 | 81 | 1 | 0.200 | 69 | 1 |

## Table 13 Background Upper Prediction Limits for Floodplain Alluvium Ground Water (Page 2 of 2)

| Analyte | Distribution | Records | Percent Non-det. | UPL Type | UPL_K=1 | %Conf. | Resamples | UPL_k=5 | % Conf. | Resamples | UPL_k=10 | %Conf. | Resamples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pb (mg/L) | 0 | 22 | 95.5 | 2 | 0.005 | 96 | 0 | 0.005 | 81 | 1 | 0.005 | 69 | 1 |
| pH (field values) | 4 | 37 | 0 | 2 | 7.920 | 97 | 0 | 7.920 | 88 | 1 | 7.920 | 79 | 1 |
| pH (field values -LPLs) | 4 | 37 | 0 | 2 | 6.650 | 97 | 0 | 6.650 | 88 | 1 | 6.650 | 79 | 1 |
| Ra-Combined (pCi/L) | 0 | 22 | 95.5 | 2 | 4.700 | 96 | 0 | 4.700 | 81 | 1 | 4.700 | 69 | 1 |
| Ra226 (pCi/L) | 0 | 22 | 54.5 | 2 | 1.300 | 96 | 0 | 1.300 | 81 | 1 | 1.300 | 69 | 1 |
| Ra228 (pCi/L) | 0 | 22 | 100 | 2 | 4.700 | 96 | 0 | 4.700 | 81 | 1 | 4.700 | 69 | 1 |
| Sb (mg/L) | 0 | 22 | 90.9 | 2 | 0.005 | 96 | 0 | 0.005 | 81 | 1 | 0.005 | 69 | 1 |
| Se (mg/L) | 0 | 22 | 90.9 | 2 | 0.005 | 96 | 0 | 0.005 | 81 | 1 | 0.005 | 69 | 1 |
| Silica (mg/L) | 4 | 22 | 0 | 2 | 57.0 | 96 | 0 | 57.0 | 81 | 1 | 57.0 | 69 | 1 |
| Sulfate (mg/L) | 4 | 38 | 0 | 2 | 79.0 | 97 | 0 | 79.0 | 88 | 1 | 79.0 | 79 | 1 |
| Sr (mg/L) | 3 | 22 | 0 | 4 | 0.682 | 95 | 0 | 0.853 | 95 | 0 | 0.932 | 95 | 0 |
| TDS (mg/L) | 4 | 29 | 0 | 2 | 508 | 97 | 0 | 508 | 85 | 1 | 508 | 74 | 1 |
| Th230 (pCi/L) | 0 | 22 | 86.4 | 2 | 5.5 | 96 | 0 | 5.5 | 81 | 1 | 5.5 | 69 | 1 |
| Tl (mg/L) | 0 | 22 | 95.5 | 2 | 0.013 | 96 | 0 | 0.013 | 81 | 1 | 0.013 | 69 | 1 |
| U (mg/L) | 3 | 38 | 23.7 | 2 | 0.0440 | 97 | 0 | 0.0440 | 88 | 1 | 0.0440 | 79 | 1 |
| V (mg/L) | 0 | 22 | 100 | 2 | 0.100 | 96 | 0 | 0.100 | 81 | 1 | 0.100 | 69 | 1 |
| Zn (mg/L) | 4 | 22 | 27.3 | 2 | 6.070 | 96 | 0 | 6.070 | 81 | 1 | 6.070 | 69 | 1 |

Note: See Table F-5-21 (Appendix F) for a description of abbreviations and codes used in this table.

**Table 14 Background Upper Prediction Limits for Sweetwater River Surface Water, 1982-1997** (Page 1 of 2)

| Analyte | Distribution | Records | Percent Non-det. | UPL Type | UPL, k=1 | %Conf. | Resamples | UPL, k=5 | % Conf. | Resamples | UPL, k=10 | % Conf. | Resamples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ag (mg/L) | 0 | 21 | 95.2 | 2 | 0.050 | 95 | 0 | 0.050 | 81 | 1 | 0.050 | 68 | 1 |
| Al (mg/L) | 0 | 35 | 100 | 2 | 0.10 | 97 | 0 | 0.10 | 88 | 1 | 0.10 | 78 | 1 |
| Alkalinity as $CaCO_3$ (mg/L) | 4 | 17 | 0 | 2 | 114 | 94 | 1 | 114 | 77 | 1 | 114 | 63 | 2 |
| As (mg/L) | 0 | 39 | 82.1 | 2 | 0.010 | 98 | 0 | 0.010 | 89 | 1 | 0.010 | 80 | 1 |
| B (mg/L) | 3 | 17 | 23.5 | 2 | 0.30 | 94 | 1 | 0.30 | 77 | 1 | 0.30 | 63 | 2 |
| Ba (mg/L) | 0 | 38 | 76.3 | 2 | 0.10 | 97 | 0 | 0.10 | 88 | 1 | 0.10 | 79 | 1 |
| Be (mg/L) | 0 | 21 | 100 | 2 | 0.010 | 95 | 0 | 0.010 | 81 | 1 | 0.010 | 68 | 1 |
| Ca (mg/L) | 4 | 49 | 0.0 | 2 | 54.0 | 98 | 0 | 54.0 | 91 | 1 | 54.0 | 83 | 1 |
| Cd (mg/L) | 0 | 38 | 100 | 2 | 0.010 | 97 | 0 | 0.010 | 88 | 1 | 0.010 | 79 | 1 |
| Cl (mg/L) | 4 | 61 | 0 | 2 | 26.0 | 98 | 0 | 26.0 | 92 | 1 | 26.0 | 86 | 1 |
| Conductivity (µS/cm) | 4 | 54 | 0 | 2 | 827 | 98 | 0 | 827 | 92 | 1 | 827 | 84 | 1 |
| Cr (mg/L) | 0 | 38 | 95 | 2 | 0.050 | 97 | 0 | 0.050 | 88 | 1 | 0.050 | 79 | 1 |
| Cu (mg/L) | 0 | 18 | 100 | 2 | 0.010 | 95 | 1 | 0.010 | 78 | 1 | 0.010 | 64 | 2 |
| Fluoride (mg/L) | 4 | 17 | 6 | 2 | 0.36 | 94 | 1 | 0.36 | 77 | 1 | 0.36 | 63 | 2 |
| Fe (mg/L) | 4 | 35 | 20 | 2 | 0.35 | 97 | 0 | 0.35 | 88 | 1 | 0.35 | 78 | 1 |
| Hg (mg/L) | 0 | 35 | 100 | 2 | 0.001 | 97 | 0 | 0.001 | 88 | 1 | 0.001 | 78 | 1 |
| K (mg/L) | 4 | 49 | 0 | 2 | 17.3 | 98 | 0 | 17.3 | 91 | 1 | 17.3 | 83 | 1 |
| Mg (mg/L) | 4 | 49 | 0 | 2 | 9.10 | 98 | 0 | 9.10 | 91 | 1 | 9.10 | 83 | 1 |
| Mn (mg/L) | 0 | 35 | 71 | 2 | 0.40 | 97 | 0 | 0.40 | 88 | 1 | 0.40 | 78 | 1 |
| Mo (mg/L) | 0 | 38 | 100 | 2 | 0.10 | 97 | 0 | 0.10 | 88 | 1 | 0.10 | 79 | 1 |
| Na (mg/L) | 4 | 49 | 0 | 2 | 37.0 | 98 | 0 | 37.0 | 91 | 1 | 37.0 | 83 | 1 |
| $NH_4$-N (mg/L) | 0 | 48 | 75 | 2 | 0.45 | 98 | 0 | 0.45 | 91 | 1 | 0.45 | 83 | 1 |
| Ni (mg/L) | 0 | 39 | 100 | 2 | 0.050 | 98 | 0 | 0.050 | 89 | 1 | 0.050 | 80 | 1 |
| $NO_2$+$NO_3$-N (mg/L) | 0 | 10 | 90 | 2 | 0.20 | 91 | 1 | 0.20 | 67 | 2 | 0.20 | 50 | 2 |

**Table 14 Background Upper Prediction Limits for Sweetwater River Surface Water, 1982-1997** (Page 2 of 2)

| Analyte | Distribution | Records | Percent Non-det. | UPL Type | UPL, k=1 | %Conf. | Resamples | UPL, k=5 | % Conf. | Resamples | UPL, k=10 | % Conf. | Resamples |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $NO_2$-N (mg/L) | 3 | 18 | 44 | 2 | 0.014 | 95 | 1 | 0.014 | 78 | 1 | 0.014 | 64 | 2 |
| $NO_3$-N (mg/L) | 4 | 44 | 48 | 2 | 0.95 | 98 | 0 | 0.95 | 90 | 1 | 0.95 | 81 | 1 |
| Pb (mg/L) | 0 | 39 | 100 | 2 | 0.050 | 98 | 0 | 0.050 | 89 | 1 | 0.050 | 80 | 1 |
| Pb-210 (pCi/L) | 3 | 17 | 0 | 4 | 1.7 | 95 | 0 | 2.1 | 95 | 0 | 2.2 | 95 | 0 |
| pH (field values) | 4 | 51 | 0 | 2 | 9.24 | 98 | 0 | 9.24 | 91 | 1 | 9.24 | 84 | 1 |
| pH (field values: LPLs) | 4 | 51 | 0 | 2 | 6.54 | 98 | 0 | 6.54 | 91 | 1 | 6.54 | 84 | 1 |
| Po-210 (pCi/L) | 4 | 17 | 0 | 2 | 1.50 | 94 | 1 | 1.50 | 77 | 1 | 1.50 | 63 | 2 |
| Ra-Combined (pCi/L) | 0 | 16 | 69 | 2 | 4.00 | 94 | 1 | 4.00 | 76 | 1 | 4.00 | 62 | 2 |
| Ra-226 (pCi/L) | 4 | 38 | 37 | 2 | 2.40 | 97 | 0 | 2.40 | 88 | 1 | 2.40 | 79 | 1 |
| Ra-228 (pCi/L) | 0 | 21 | 71 | 2 | 3.8 | 95 | 0 | 3.8 | 81 | 1 | 3.8 | 68 | 1 |
| Se (mg/L) | 0 | 38 | 97 | 2 | 0.005 | 97 | 0 | 0.005 | 88 | 1 | 0.005 | 79 | 1 |
| Silica (mg/L) | 4 | 8 | 0 | 2 | 22.1 | 89 | 1 | 22.1 | 62 | 2 | 22.1 | 44 | 3 |
| Sulfate (mg/L) | 4 | 62 | 0 | 2 | 73.0 | 98 | 0 | 73.0 | 93 | 1 | 73.0 | 86 | 1 |
| TDS (mg/L) | 4 | 62 | 0 | 2 | 391 | 98 | 0 | 391 | 93 | 1 | 391 | 86 | 1 |
| Th-230 (pCi/L) | 4 | 38 | 47 | 2 | 2.30 | 97 | 0 | 2.30 | 88 | 1 | 2.30 | 79 | 1 |
| U (mg/L) | 3 | 39 | 13 | 4 | 0.0643 | 95 | 0 | 0.1327 | 95 | 0 | 0.1753 | 95 | 0 |
| V (mg/L) | 0 | 17 | 100 | 2 | 0.10 | 94 | 1 | 0.10 | 77 | 1 | 0.10 | 63 | 2 |
| Zn (mg/L) | 0 | 18 | 72 | 2 | 0.020 | 95 | 1 | 0.020 | 78 | 1 | 0.020 | 64 | 2 |

Note: See Table F-8-12 (Appendix F) for a descritpion of abbreviations and codes used in this table.

## Table 15 Corrective Action Alternatives Detailed Analysis Summary

| Alternative Criteria | Institutional Control Only | Hydraulic Diversion With Institutional Control | Focused Pumping with Institutional Control | Perpetual Containment With Institutional Control |
|---|---|---|---|---|
| **Protective** | Yes | Yes | Yes | Yes |
| **ALARA** | | | | |
| **Costs:** | | | | |
| **Monetary Costs:** | $114,000 | $17,910,000 | $107,850,000 | $117,350,000 |
| **Non-monetary costs:** | | | | |
| Aesthetic Impacts | None | Low (perpetual) | High (25 + yrs) | Very High (perpetual) |
| Worker Health Impacts | None | Low | Moderate | High |
| Environmental Impacts | None | Low | High | Moderate – High |
| **Resource Value:** | | | | |
| Ground Water Consumption | None | Evap. Loss = None<br>Extract. Loss = 250 gpm (1,000 yrs) | Evap. Loss = 1,876 gpm (25 yrs)<br>Extract. Loss = None | Evap. Loss = 265 gpm (25 yrs)<br>Evap. Loss = 35 gpm (1,000 yrs)<br>Extract. Loss = None |
| Total Control Area | 5,275 acres | 2,795 acres | 3,818 acres | 2,965 acres |
| **Benefit:** | | | | |
| Socioeconomic Benefits | None | Low | Moderate | Moderate |
| [1]Restored Ground Water Resource Area | 0 | 2,480 acres | 1,457 acres | 2,310 acres |
| [2]Restored Ground Water Resource Value | $0 | $302,560 | $177,750 | $281,820 |

Notes: [1]Restored Ground Water Area is the difference in Ground Water Resource Control Area between Baseline Institutional Control Alternative and other alternatives.
[2]Ground Water Resource Value is assumed to be equal to land values of Restored Ground Water Resource Area, based on present average land values of $122/acre.

## TABLE 16 Protective Northwest Valley Groundwater Concentrations Under Worst-case Conditions

| | (A) River Background (mg/L) | (B) Protective Aquatic Acute Value (mg/L) | (C) (River minimum low flow) (210 gpm from NWV) (No attenuation) River Concentration With NWV Groundwater At ACL Values (mg/L) | (D) Proposed Northwest Valley ACL Concentrations (mg/L) | (E) Factor of Safety |
|---|---|---|---|---|---|
| U | 0.064 | 2.6 | 1.11 | 4.75 | 2.3 |
| Ra-226 | 4 pCi/L | NA | NA | 7.2 pCi/L | NA |
| Mn | 0.4 | 1,000 | 50.44 | 225 | 19.8 |
| Mo | 0.1 | 16 | 0.22 | 0.66 | 71.2 |
| $NH_3$ | 0.45 | 2.13 | 0.49 | 0.61 | 4.4 |
| $NO_3$ | 0.95 | 100 | 71.37 | 317 | 1.4 |

**River Minimum Low- flow Rate:** **2.1 cfs**
**942.48 gpm** (F)
**5,130,107 L/day**

**Current NWV Groundwater Flux** **210 gpm** (G)
**1,143,072 L/day**

NA = No applicable standard available.

**Note:**
This calculation assumes all of the Northwest Valley (NWV) flow is at the ACL concentration. This is highly conservative as the POC wells monitor valley ground water concentrations several times larger than valley average concentrations. In addition, this calculation assumes no attenuation of valley constituents in transport to the river. Site specific testing (Appendix F) demonstrates that constituents exhibit some attenuation in transport. Further, this calculation uses 1996 Northwest Valley ground water flux rates (210 gpm) which have decreased and will continue to decrease to steady state values of approximately 100 gpm.

**Note:**
C =([A x (F - G)] + [D x G ]) / F          E = B / D

**Note**
Protective uranium value is 20 percent of the LC-50 for brook trout at a hardness of 100 mg/L, from Parkhurst et al., 1984.
Protective manganese value for fish from Hapke, 1987.
Protective molybdenum value for aquatic life is EPA Teir II (acute) value, Suter and Tsao, 1996.
Protective ammonia value is National Ambient Water Quality Acute Criteria for ammonia at pH = 8.5, with sensitive species (EPA, 1998; EPA-882-R-98-008)
Protective nitrate value is from Pierce et al., 1993; no effects reported for fish below 100 mg/L $MnO_3$.

**Table 17 Summary of Proposed Protective Standards for Ground Water Compliance** (Page 1 of 2)

| Constituents | Maximum Concentration From Tailing Area (mg/L) | Maximum Concentration Beyond Edge of Tailing Reclamation (mg/L) | Background Concentrations | | Proposed Protective Standards | |
|---|---|---|---|---|---|---|
| | | | Floodplain Alluvial Aquifer (mg/L) | Split Rock Formation Aquifer (mg/L) | Northwest Valley (mg/L) | Southwest Valley (mg/L) |
| Aluminum | 578 | 2.02 | 0.1 | 0.13 | 37 (RBC)[a] | 37 (RBC)[a] |
| Ammonia | 0.16 | 2.35 | 0.011 | 0.015 | **0.61** | **0.84** |
| Antimony | 0.017 | 0.01 | 0.005 | 0.005 | 0.006 (MCL)[b] | 0.006 (MCL)[b] |
| Arsenic | 2.64 | 0.058 | 0.024 | 0.1 | 0.05 (MCL) | 0.05 (MCL) |
| Beryllium | 0.084 | <0.01[c] | 0.004 | 0.01 | 0.004 (MCL) | 0.004 (MCL) |
| Cadmium | 0.188 | 0.014 | 0.008 | 0.014 | 0.005 (MCL) | 0.005 (MCL) |
| Fluoride | 21.7 | 1.33 | 1.04 | 0.517 | 4 (MCL) | 4 (MCL) |
| Lead | 0.11 | 0.005 | 0.005 | 0.050 | 0.015 (MCL[d]) | 0.015 (MCL[d]) |
| Manganese | 126 | 49.1 | 2.39 | 0.53 | **225** | **35** |
| Molybdenum | 0.55 | 0.22 | 0.1 | 0.1 | **0.66** | 0.1 |
| Nickel | 2.29 | 0.11 | 0.05 | 0.05 | 0.73 (RBC) | 0.73 (RBC) |
| Nitrate | 362 | 201 | 0.88 | 3.99 | **317** | **71** |

**Table 17 Summary of Proposed Protective Standards for Ground Water Compliance** (Page 2 of 2)

| Constituents | Maximum Concentration From Tailing Area (mg/L) | Maximum Concentration Beyond Edge of Tailing Reclamation (mg/L) | Background Concentrations | | Proposed Protective Standards | |
|---|---|---|---|---|---|---|
| | | | Floodplain Alluvial Aquifer (mg/L) | Split Rock Formation Aquifer (mg/L) | Northwest Valley (mg/L) | Southwest Valley (mg/L) |
| Radium 226 +228 | 2950 pCi/L | 13.5 | 4.7 | 5.3 | **7.2** pCi/L | **19.9** pCi/L |
| Selenium | 0.119 | 0.061 | 0.005 | 0.011 | 0.05 (MCL) | 0.05 (MCL) |
| Thallium | 0.075 | 0.013 | 0.013 | 0.003 | 0.002 (MCL) | 0.002 (MCL) |
| Thorium 230 | 732 pCi/L | 5.5 | 5.5 | 1.8 | 15 pCi/L (MCL[e]) | 15 pCi/L (MCL[e]) |
| Uranium (natural) | 4.055 | 8.7 | 0.044 | 0.13 | **4.75** | **3.4** |

Notes: [a]RBC = risk-based concentration

[b]MCL = maximum concentration limit

[c]Number is highest detection limit (DL), all analyses <DL, all analyses are <DL with almost all DL ≤ protective standard

[d]0.015 mg/L level for lead is technically not an MCL but an EPA Action Level

[e]There is an EPA MCL value of 15 pCi/L for gross alpha; gross alpha would include both $Th^{230}$ and $Ra^{226+228}$. Assuming the limit of 5 pCi for $Ra^{226+228}$ would allow for 10 pCi gross alpha from $Th^{230}$.

**Table 18 Maximum Historical Ground Water Concentrations for Proposed Point Of Compliance and Other Wells**

| COC | Protective Aquatic Acute Values | Northwest Valley | | Southwest Valley | |
|---|---|---|---|---|---|
| | | Well 4/4R | WN-5 | WN-B | WN-21 |
| $U_{nat}$ (mg/L) | 2.6 | 2.67 | **4.75** (1983) | **3.4** (1982) | 1.15 |
| Ra-226+228 (pCi/L) | NA | 7.2 | **7.2** (1992) | **19.9** (1993) | 3.7 |
| Mn (mg/L) | 1,000 | **225** (1983) | 0.25 | **35** (1982) | 10.2 |
| Mo (mg/L) | 16 | 0.6 | **0.66** (1982) | <0.1 | <0.1 |
| $NH_3$ (mg/L) | 2.13 | **0.61** (1996) | 0.003 | 0.19 | **0.84** (1997) |
| $NO_3$ (mg/L) | 100 | **317**(1995) | 264 | **70.7** (1991) | 35.6 |

FIGURES

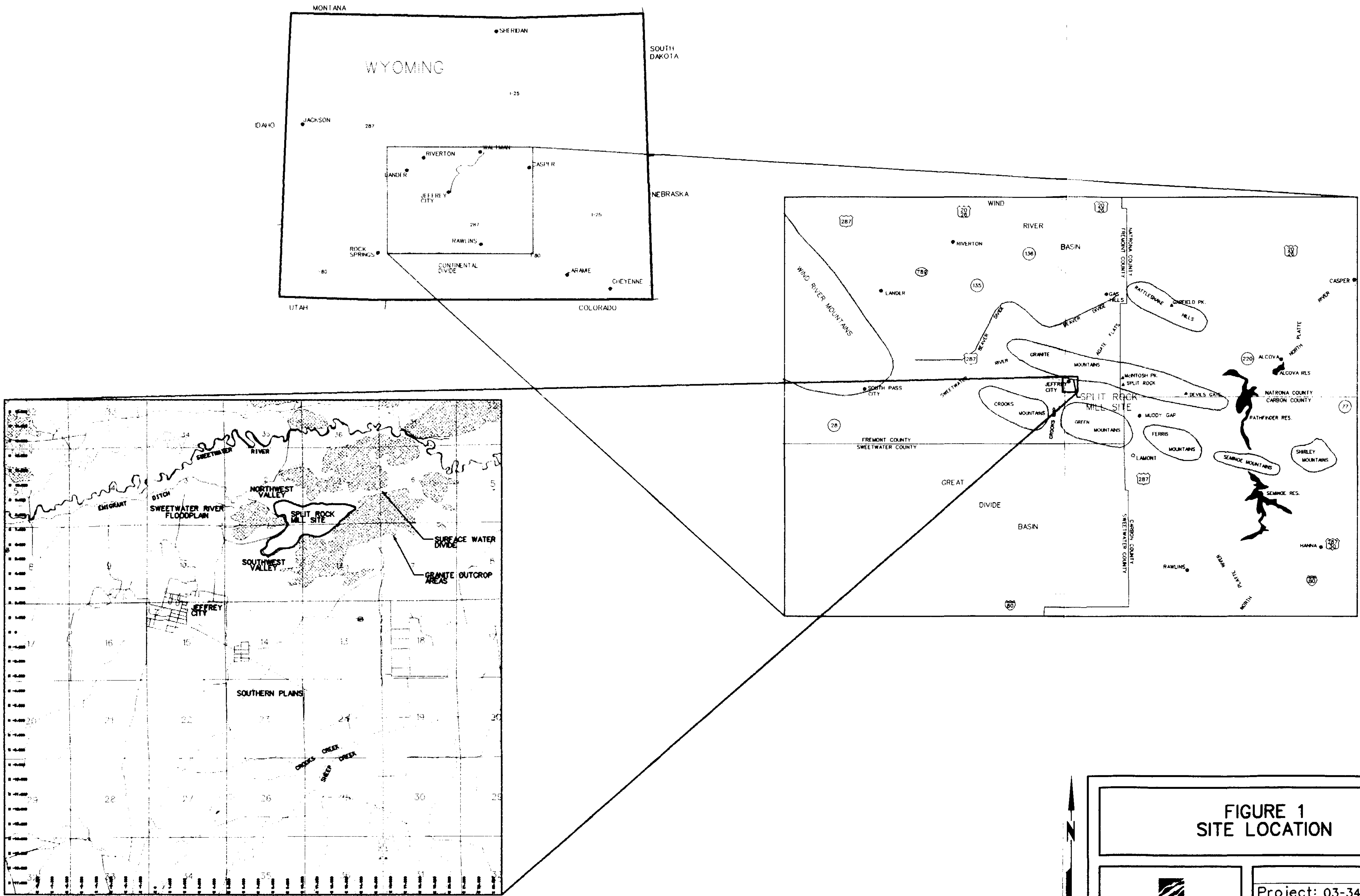
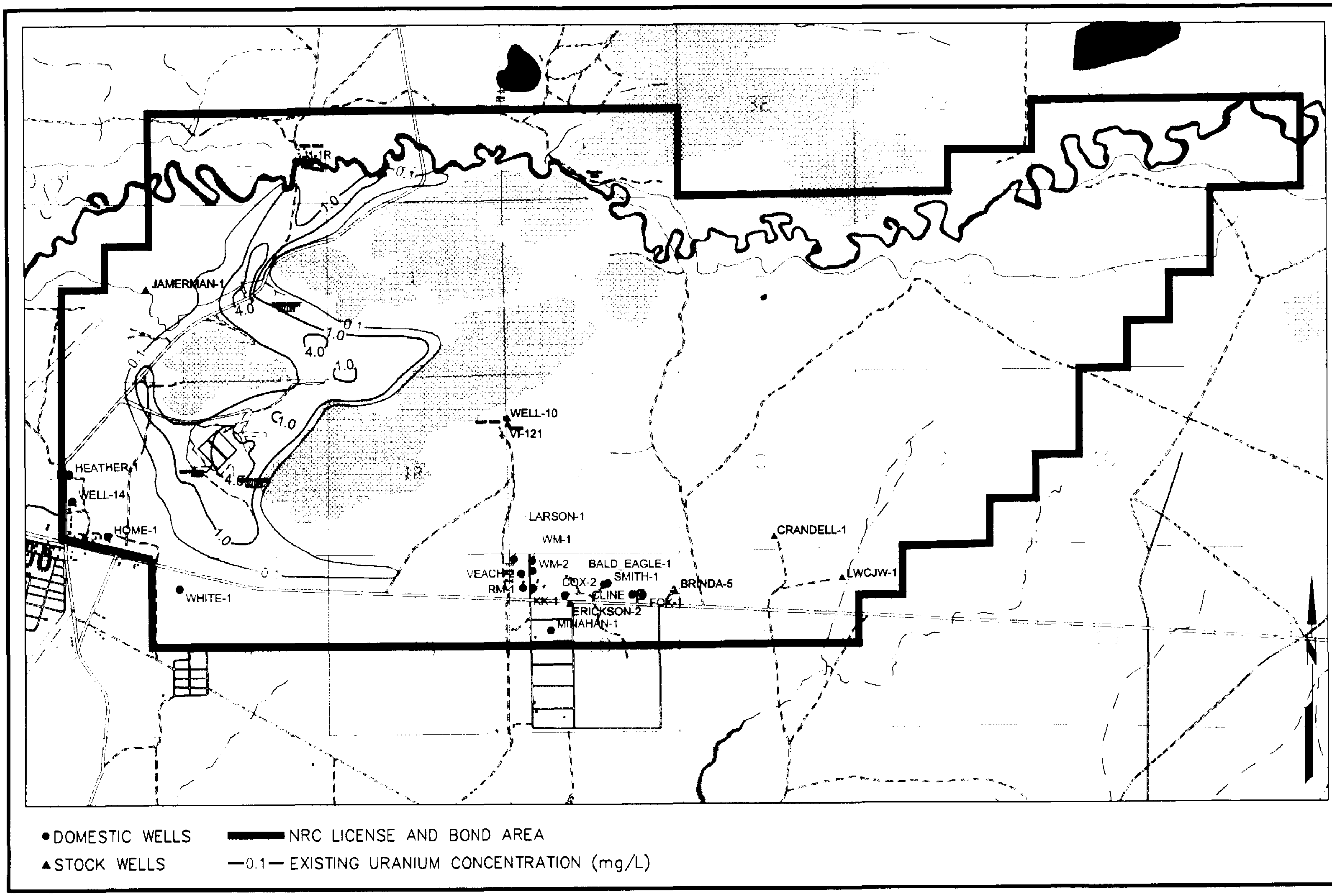



FIGURE 1
SITE LOCATION

SHEPHERD MILLER

Project: 03-347
File: SITELOC.DGN
Query: N/A




SHEPHERD MILLER
INCORPORATED

**FIGURE 2**
**DOMESTIC AND STOCK WELLS**

| | |
|---|---|
| Project: | 03-347\TASK3 |
| File: | DOM-STCK-2.DWG |

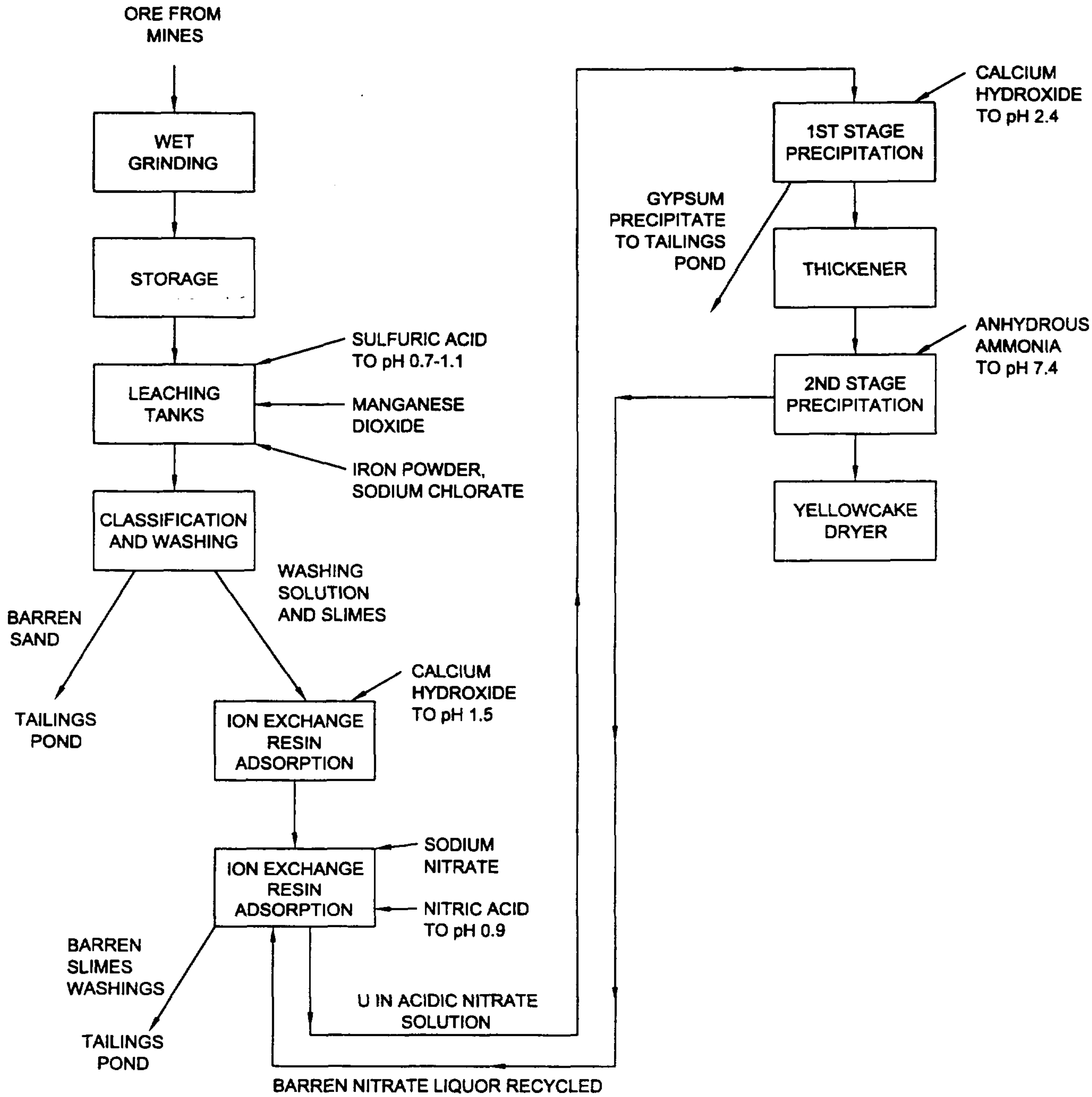
# OVERSIZE PAGE(S)

***********************

**NOT CONVERTED INTO ELECTRONIC IMAGE FORM.**

***********************

**PAPER COPY IS AVAILABLE IN NRC FILE CENTER.**




SOURCE: FLOW CHART BASED ON PROCESS DESCRIPTION IN DENVER EQUIPMENT COMPANY, 1961 (EST.)

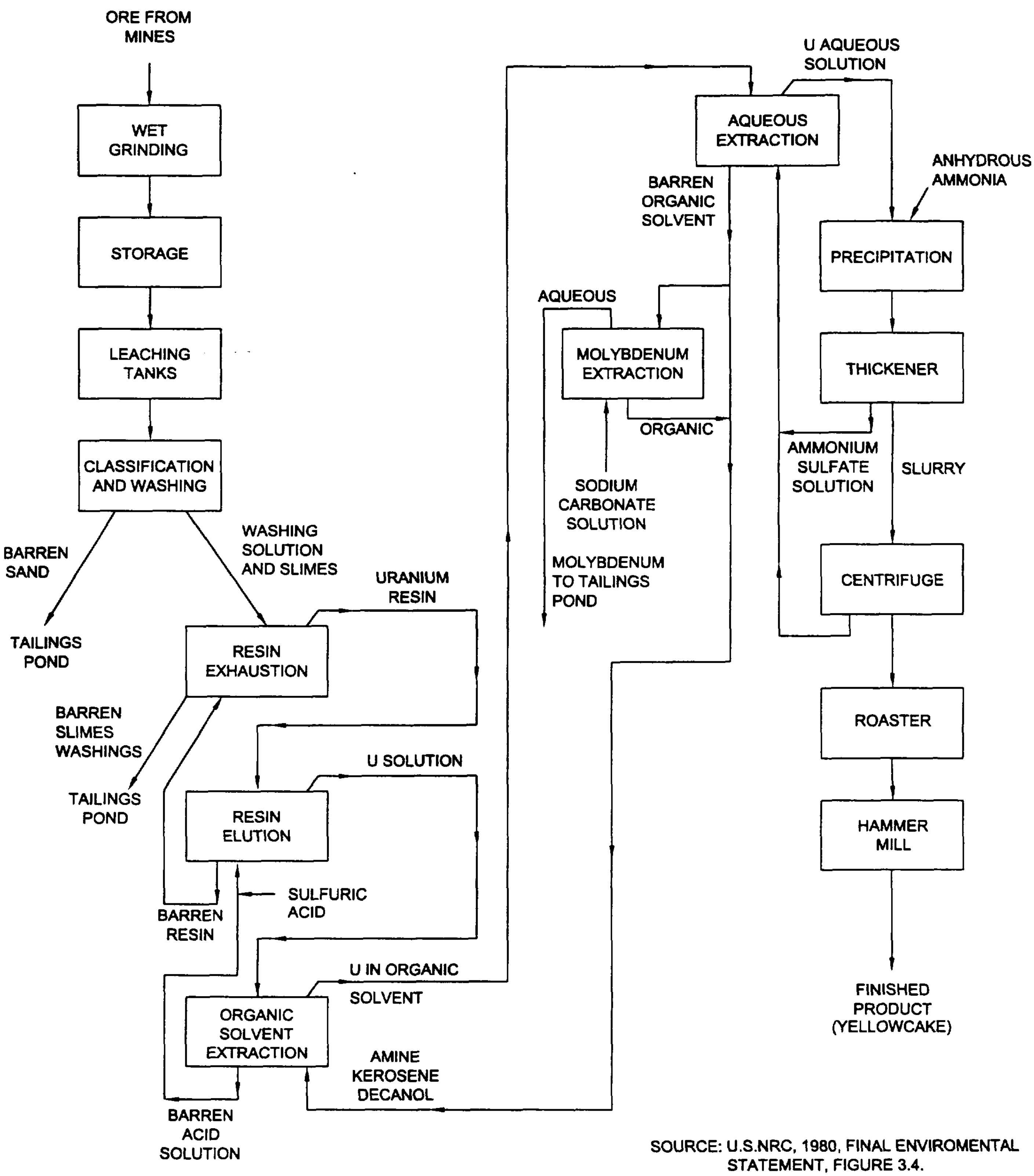
SHEPHERD MILLER INCORPORATED

**FIGURE 4**

SIMPLIFIED FLOW DIAGRAM OF THE SPLIT ROCK MILL PROCESS CIRCUIT, APPROX. 1957 - 1965

Project: 03-347\TASK8

File: PROCESS1




SOURCE: U.S.NRC, 1980, FINAL ENVIROMENTAL STATEMENT, FIGURE 3.4.

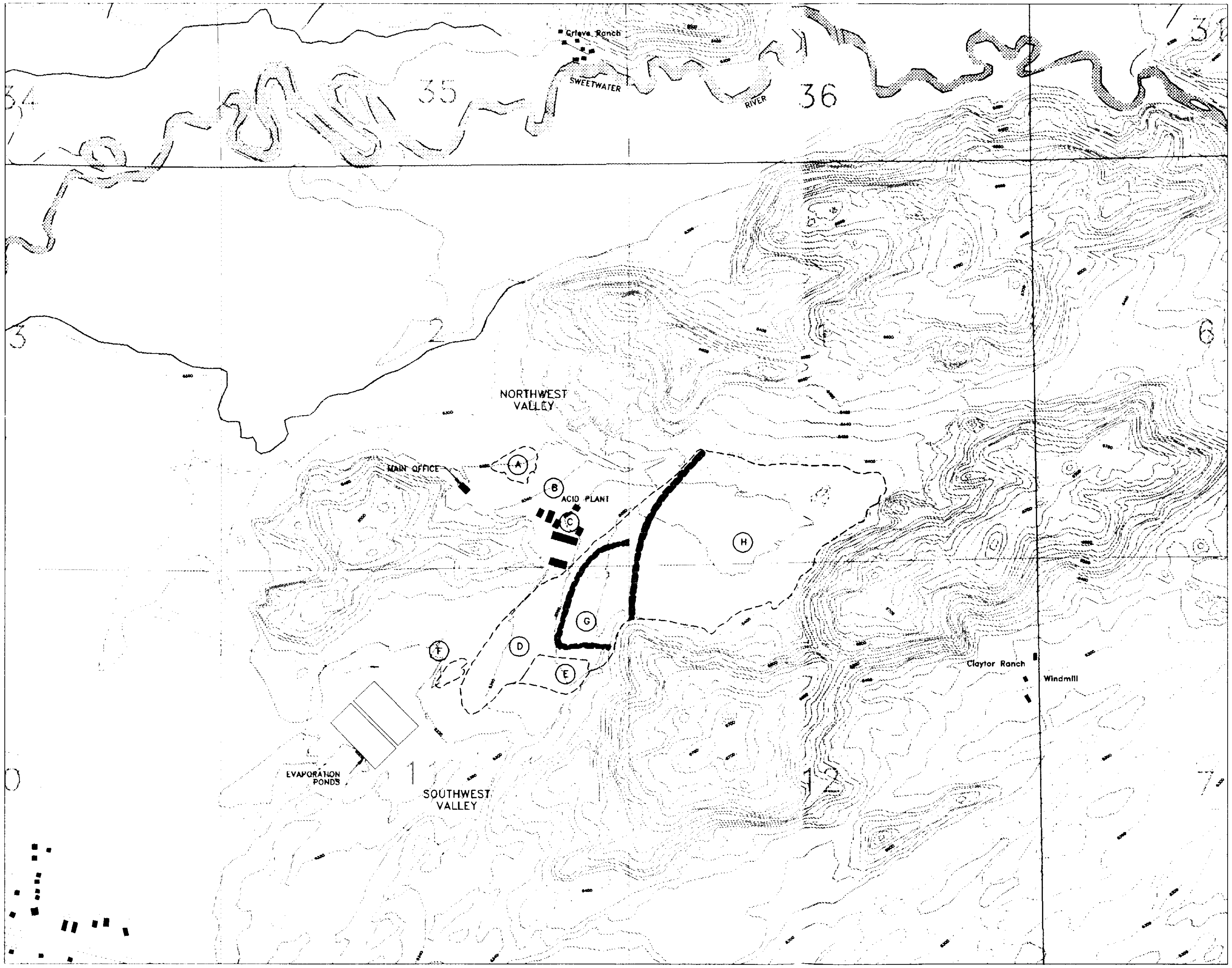
*NOTE: SODIUM CHLORATE ADDED AS OXIDIZER DURING 1960'S.

SHEPHERD MILLER INCORPORATED

**FIGURE 5**

SIMPLIFIED FLOW DIAGRAM OF THE SPLIT ROCK MILL PROCESS CIRCUIT, APPROX. 1965 - 1981

| | |
|---|---|
| Project: | 03-347\TASK8 |
| File: | PROCESS2 |




LEGEND

- (A) NORTHWEST VALLEY SEEPAGE POND
- (B) ORE PAD
- (C) SPLIT ROCK MILL COMPLEX
- (D) ALTERNATE TAILING IMPOUNDMENT
- (E) WASTE TRENCH AREA
- (F) SEWAGE LAGOON
- (G) OLD TAILING IMPOUNDMENT
- (H) MAIN TAILING IMPOUNDMENT
- — — — 1988 FACILITIES DELINEATION (SOURCE: WNI. 1987. REVISION #1 TO SPLIT ROCK MILL SITE RECLAMATION PLAN, FIG A-1)

NOTE: DECOMMISSIONING AND DEMOLITION OF THE MILL HAS BEEN COMPLETED. SURFACE RECLAMATION WAS ESSENTIALLY COMPLETED IN 1998.

N

SCALE IN FEET

1500 0 3000

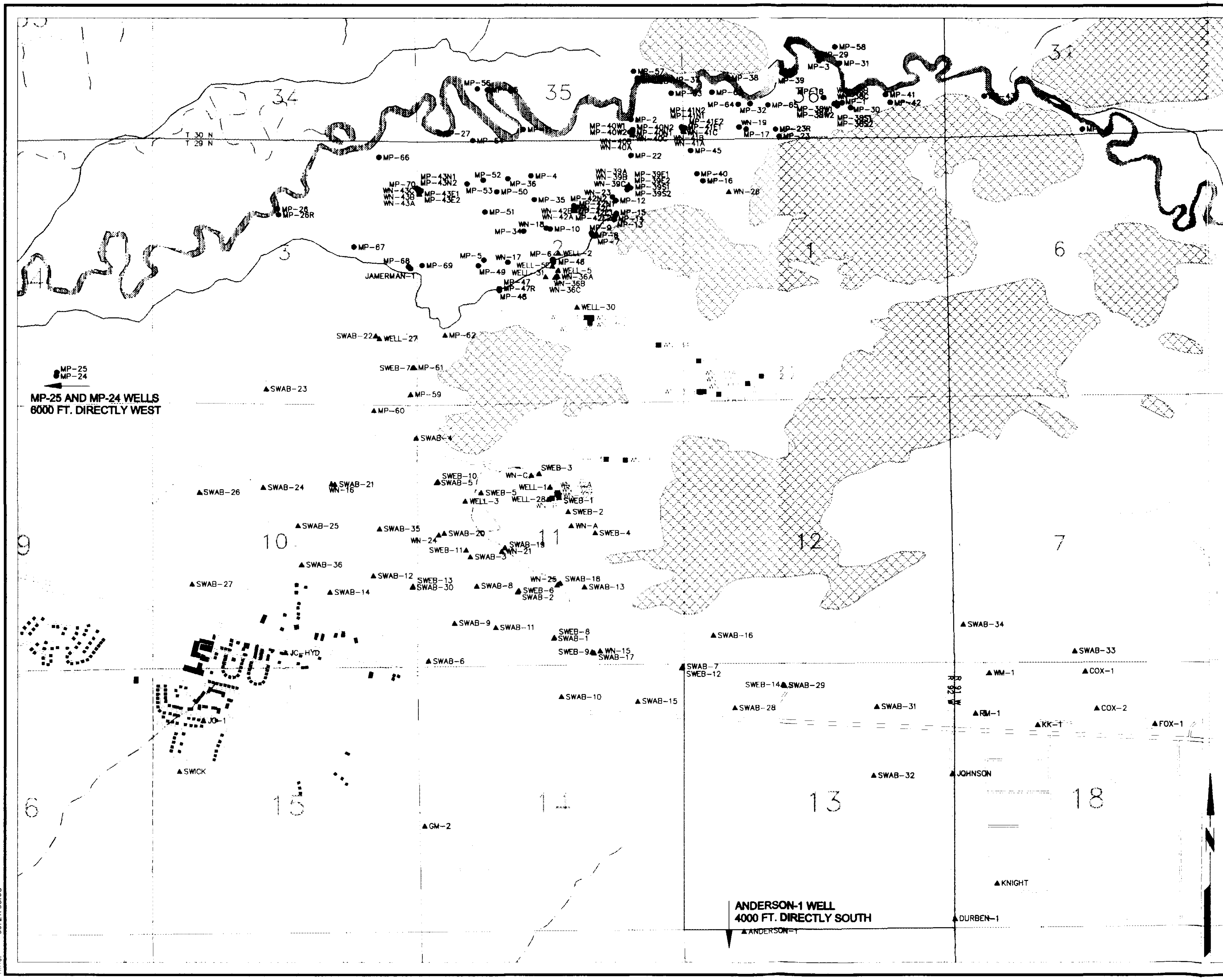
**FIGURE 6**
**HISTORICAL SITE FEATURES LOCATIONS**

SHEPHERD MILLER INCORPORATED

**Project:** 03-347/TASK8

**File:** SITEFEAT.DWG

Filename: E:\03-347\TASK8\SITEFEAT.dwg
Date: 05/26/1999
Time: 15:07:37.69




■ TAILING AND SOURCE AREA WELLS (ABOVE POC)

▲ SPLIT ROCK FORMATION AQUIFER WELLS (BELOW POC)

● FLOODPLAIN ALLUVIAL AQUIFER WELLS

SCALE IN FEET

2000 0 4000

# FIGURE 7
# WATER QUALITY SAMPLING LOCATIONS

SHEPHERD MILLER

Project: 03-347/TASK10

File: FIG-I-A-1.DWG

Filename: E:\03-347\TASK10\fig-a-1.dwg
Date: 06/04/1999
Time: 09:21:33.68

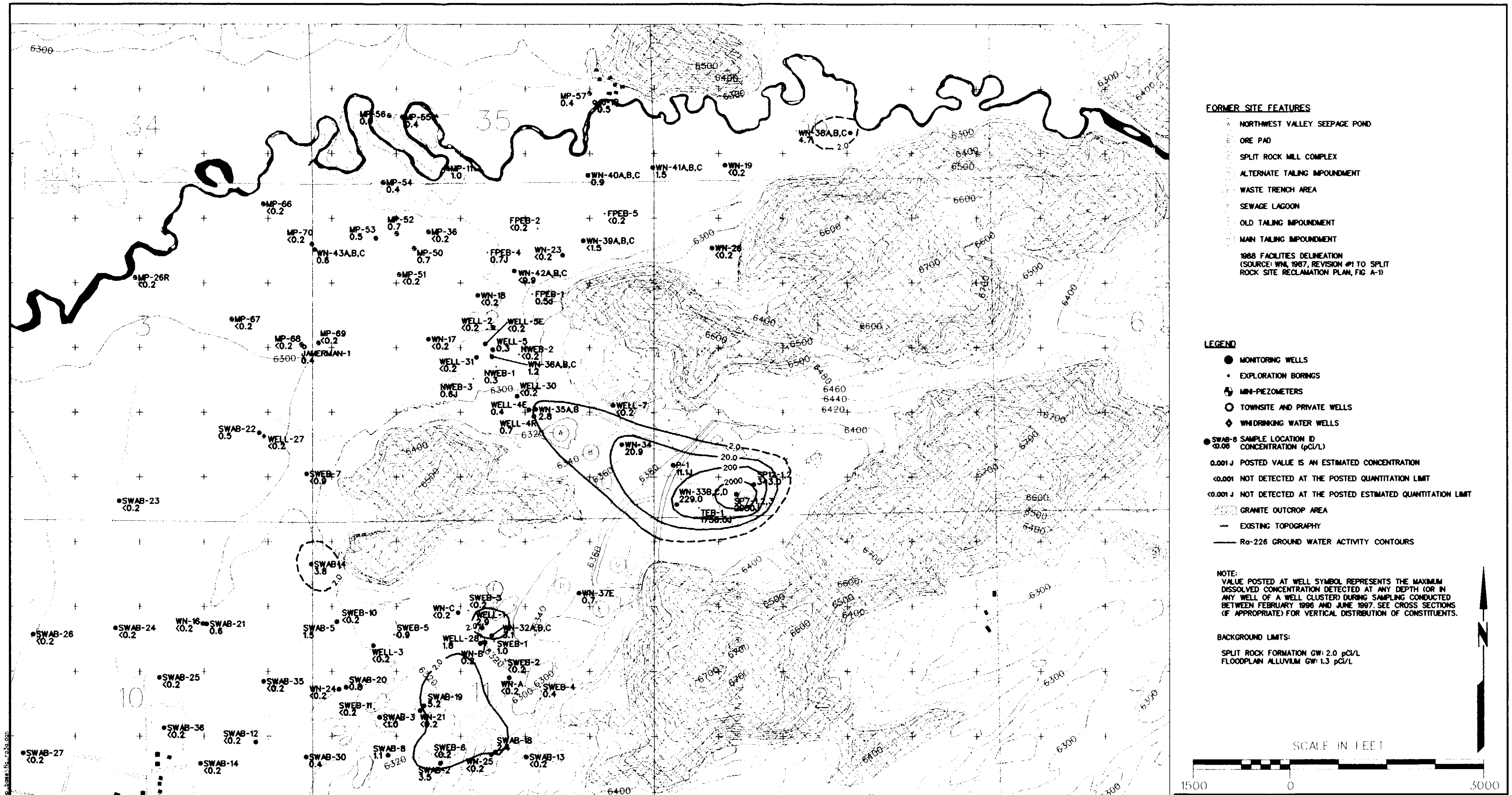
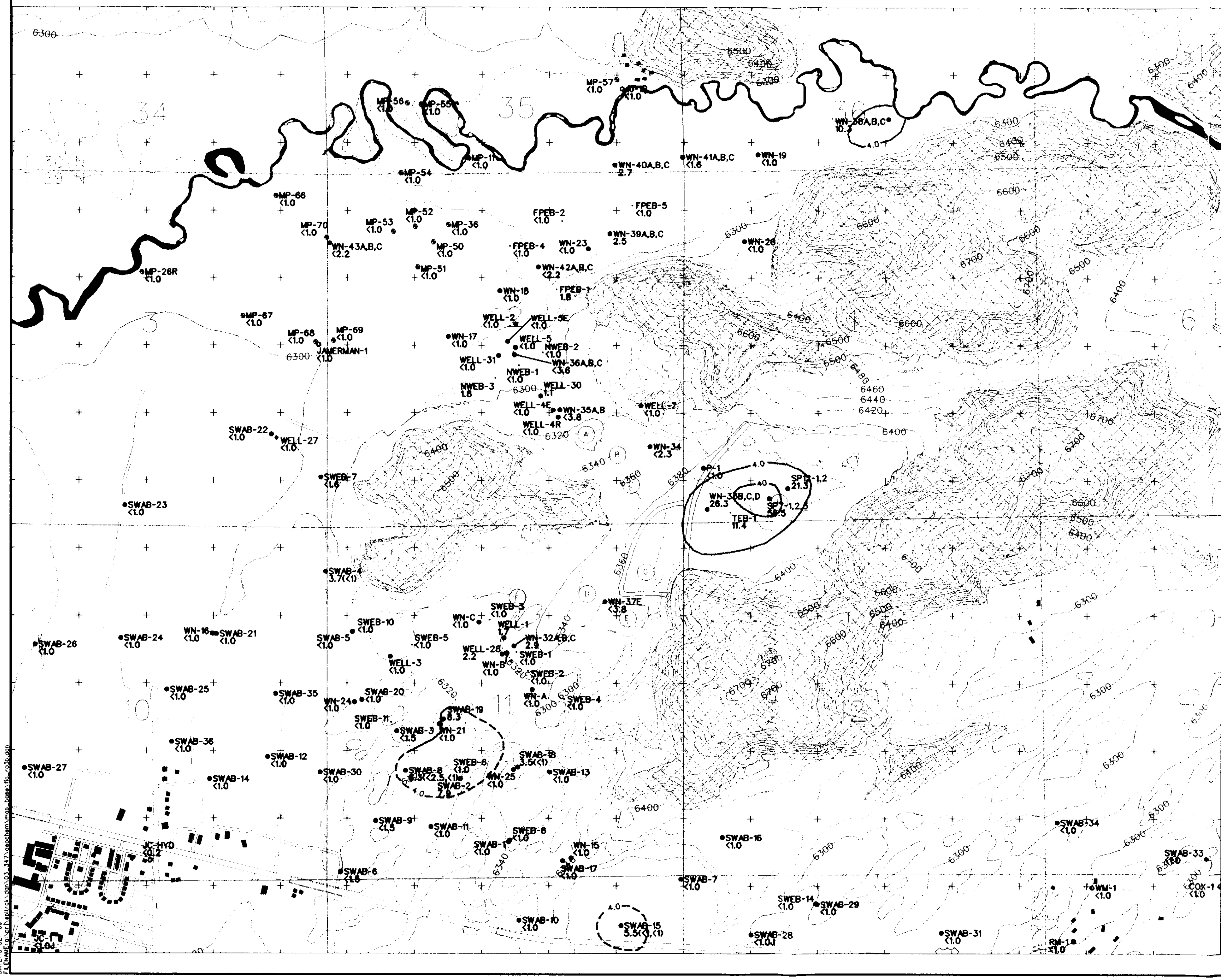



FIGURE 8
GROUND WATER Ra-226 ACTIVITIES, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER

Project: 03-347
File: FIG_RA3A
Query: RA3A_GEOCHEM




**FORMER SITE FEATURES**

- NORTHWEST VALLEY SEEPAGE POND
- ORE PAD
- SPLIT ROCK MILL COMPLEX
- ALTERNATE TAILING IMPOUNDMENT
- WASTE TRENCH AREA
- SEWAGE LAGOON
- OLD TAILING IMPOUNDMENT
- MAIN TAILING IMPOUNDMENT
- 1988 FACILITIES DELINEATION (SOURCE: WNI, 1987, REVISION #1 TO SPLIT ROCK SITE RECLAMATION PLAN, FIG A-1)

**LEGEND**

- MONITORING WELLS
- EXPLORATION BORINGS
- MINI-PIEZOMETERS
- TOWNSITE AND PRIVATE WELLS
- WNI DRINKING WATER WELLS
- SWAB-8 / <0.05 — SAMPLE LOCATION ID / CONCENTRATION (pCi/L)
- 0.001 J — POSTED VALUE IS AN ESTIMATED CONCENTRATION
- <0.001 — NOT DETECTED AT THE POSTED QUANTITATION LIMIT
- <0.001 J — NOT DETECTED AT THE POSTED ESTIMATED QUANTITATION LIMIT
- GRANITE OUTCROP AREA
- EXISTING TOPOGRAPHY
- Ra-228 GROUND WATER ACTIVITY CONTOURS

NOTE:
VALUE POSTED AT WELL SYMBOL REPRESENTS THE MAXIMUM DISSOLVED CONCENTRATION DETECTED AT ANY DEPTH (OR IN ANY WELL OF A WELL CLUSTER) DURING SAMPLING CONDUCTED BETWEEN FEBRUARY 1996 AND JUNE 1997. SEE CROSS SECTIONS (IF APPROPRIATE) FOR VERTICAL DISTRIBUTION OF CONSTITUENTS.

IF THE MAXIMUM VALUE APPEARED TO BE ANOMALOUS, OTHER RESULTS FOR THE SAME LOCATION WERE ALSO POSTED

BACKGROUND LIMITS:

SPLIT ROCK FORMATION GW: 4.7 pCi/L
FLOODPLAIN ALLUVIUM GW: 4.7 pCi/L

N

SCALE IN FEET

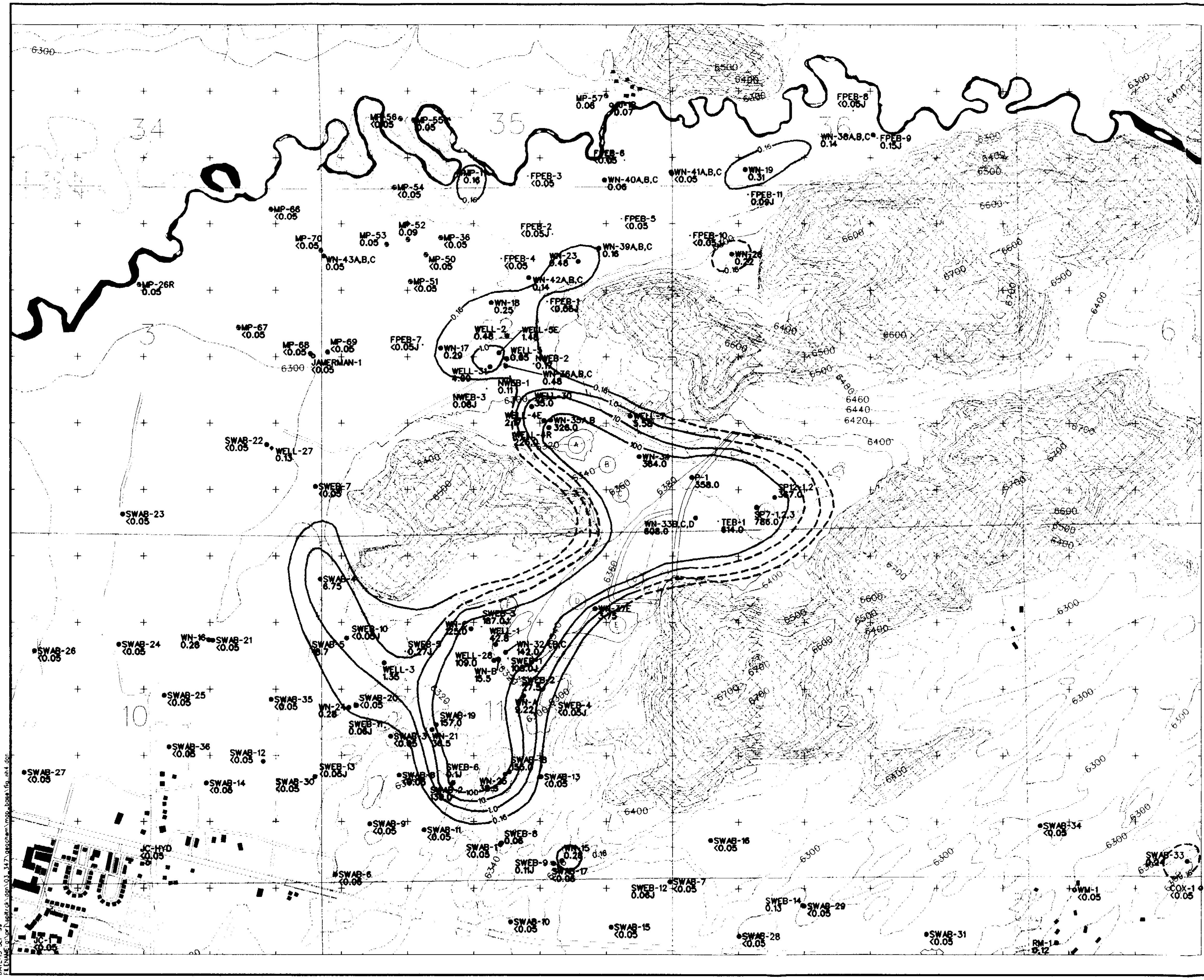
1500 0 3000

FIGURE 9
GROUND WATER Ra-228
ACTIVITIES, 1996/97,
SPLIT ROCK SITE

SHEPHERD MILLER

Project: 03-347
File: FIG_RA3B
Query: RA3B_GEOCHEM

TIME: 14:04:15
DATE: 15 SEP 99




TIME: 14:19:27
DATE: 15 SEP 99

**FORMER SITE FEATURES**

- NORTHWEST VALLEY SEEPAGE POND
- ORE PAD
- SPLIT ROCK MILL COMPLEX
- ALTERNATE TAILING IMPOUNDMENT
- WASTE TRENCH AREA
- SEWAGE LAGOON
- OLD TAILING IMPOUNDMENT
- MAIN TAILING IMPOUNDMENT
- 1988 FACILITIES DELINEATION (SOURCE: WNI, 1987, REVISION #1 TO SPLIT ROCK SITE RECLAMATION PLAN, FIG A-1)

**LEGEND**

- MONITORING WELLS
- EXPLORATION BORINGS
- MINI-PIEZOMETERS
- TOWNSITE AND PRIVATE WELLS
- WNI DRINKING WATER WELLS
- SWAB-8 <0.05 — SAMPLE LOCATION ID / CONCENTRATION (mg/L)
- 0.001 J — POSTED VALUE IS AN ESTIMATED CONCENTRATION
- <0.001 — NOT DETECTED AT THE POSTED QUANTITATION LIMIT
- <0.001 J — NOT DETECTED AT THE POSTED ESTIMATED QUANTITATION LIMIT
- GRANITE OUTCROP AREA
- EXISTING TOPOGRAPHY
- $NH_3/NH_4$ GROUND WATER CONCENTRATION CONTOURS

NOTE:
VALUE POSTED AT WELL SYMBOL REPRESENTS THE MAXIMUM DISSOLVED CONCENTRATION DETECTED AT ANY DEPTH (OR IN ANY WELL OF A WELL CLUSTER) DURING SAMPLING CONDUCTED BETWEEN FEBRUARY 1996 AND JUNE 1997. SEE CROSS SECTIONS (IF APPROPRIATE) FOR VERTICAL DISTRIBUTION OF CONSTITUENTS.

BACKGROUND LIMITS:

SPLIT ROCK FORMATION GW: 0.7 mg/L
FLOODPLAIN ALLUVIUM GW: 0.16 mg/L

N

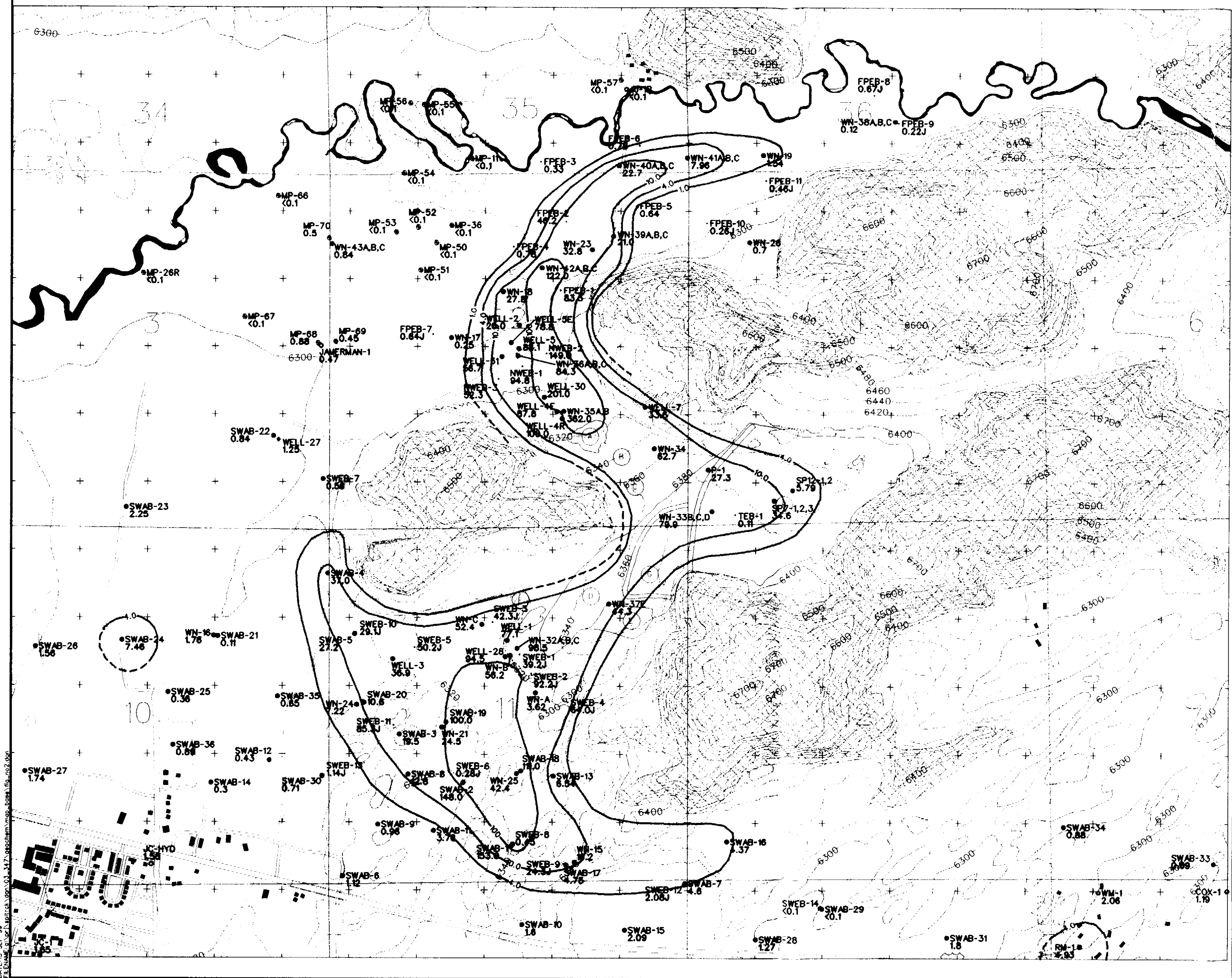
SCALE IN FEET

1500 0 3000

FIGURE 10
GROUND WATER $NH_3/NH_4$
CONCENTRATIONS, 1996/97,
SPLIT ROCK SITE

SHEPHERD MILLER

| | |
|---|---|
| Project: | 03-347 |
| File: | FIG_NH4 |
| Query: | NH4-N_GEOCHEM |



**FORMER SITE FEATURES**

- (A) NORTHWEST VALLEY SEEPAGE POND
- (B) ORE PAD
- SPLIT ROCK MILL COMPLEX
- ALTERNATE TAILING IMPOUNDMENT
- WASTE TRENCH AREA
- SEWAGE LAGOON
- OLD TAILING IMPOUNDMENT
- MAIN TAILING IMPOUNDMENT

1988 FACILITIES DELINEATION (SOURCE: WNI, 1987, REVISION #1 TO SPLIT ROCK SITE RECLAMATION PLAN, FIG A-1)

**LEGEND**

- MONITORING WELLS
- EXPLORATION BORINGS
- MINI-PIEZOMETERS
- TOWNSITE AND PRIVATE WELLS
- WNI DRINKING WATER WELLS
- SWAB-8 <0.06 SAMPLE LOCATION ID CONCENTRATION (mg/L)
- 0.001 J POSTED VALUE IS AN ESTIMATED CONCENTRATION
- <0.001 NOT DETECTED AT THE POSTED QUANTITATION LIMIT
- <0.001 J NOT DETECTED AT THE POSTED ESTIMATED QUANTITATION LIMIT
- GRANITE OUTCROP AREA
- EXISTING TOPOGRAPHY
- $NO_3 + NO_2$ GROUND WATER CONCENTRATION CONTOURS

NOTE:
VALUE POSTED AT WELL SYMBOL REPRESENTS THE MAXIMUM DISSOLVED CONCENTRATION DETECTED AT ANY DEPTH (OR IN ANY WELL OF A WELL CLUSTER) DURING SAMPLING CONDUCTED BETWEEN FEBRUARY 1996 AND JUNE 1997. SEE CROSS SECTIONS (IF APPROPRIATE) FOR VERTICAL DISTRIBUTION OF CONSTITUENTS.

CONCENTRATIONS <4.0 mg/L ARE ONLY CONTOURED IN THE FLOODPLAIN

BACKGROUND LIMITS:

SPLIT ROCK FORMATION GW: 4.0 mg/L
FLOODPLAIN ALLUVIUM GW: 0.88 mg/L

SCALE IN FEET
1500 0 3000

FIGURE 11
GROUND WATER $NO_3 + NO_2$ CONCENTRATIONS, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER

Project: 03-347
File: FIG_NO2
Query: NO2+NO3-N_GEOCHEM

TIME: 14:20:20
DATE: 15 SEP 99

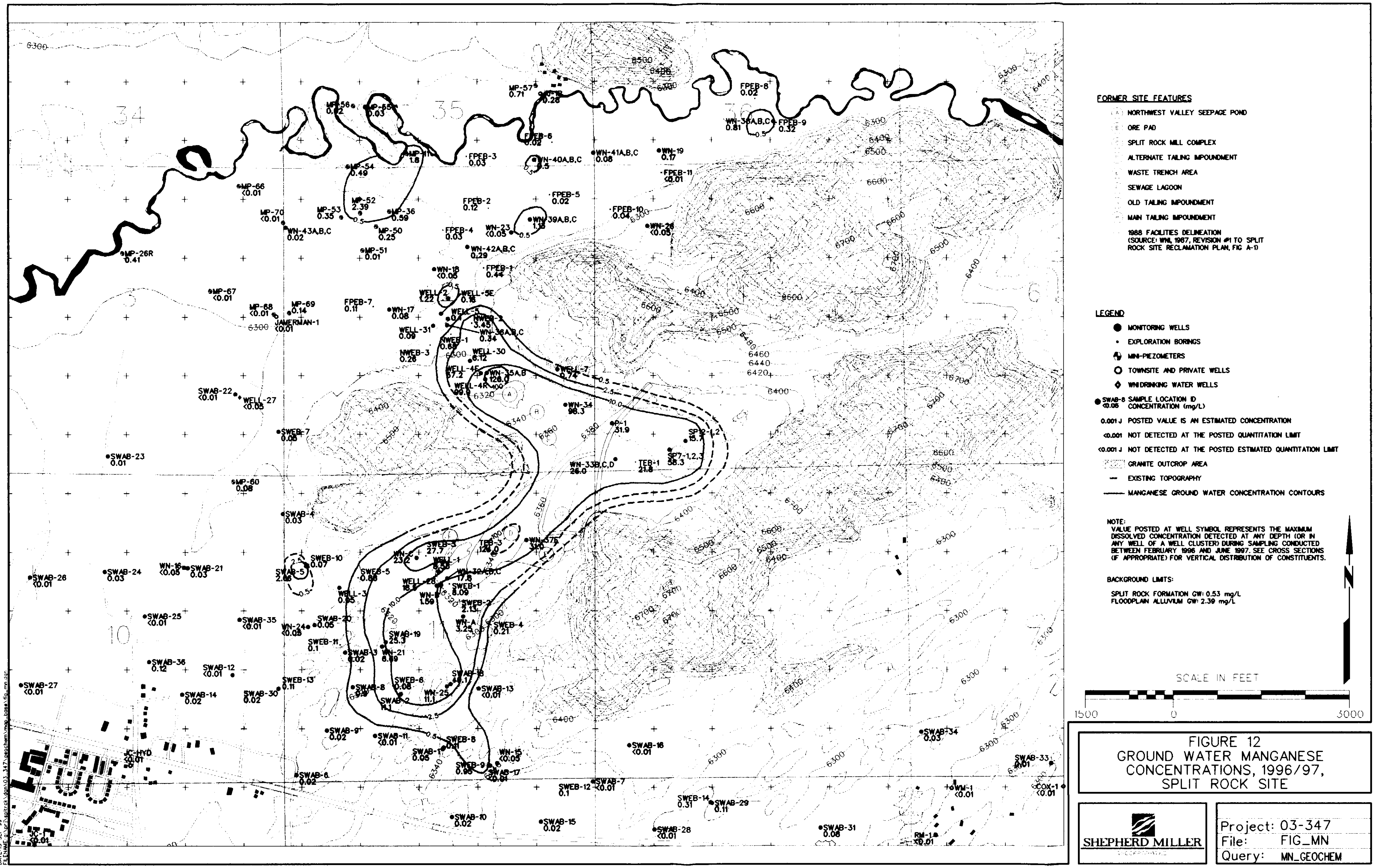
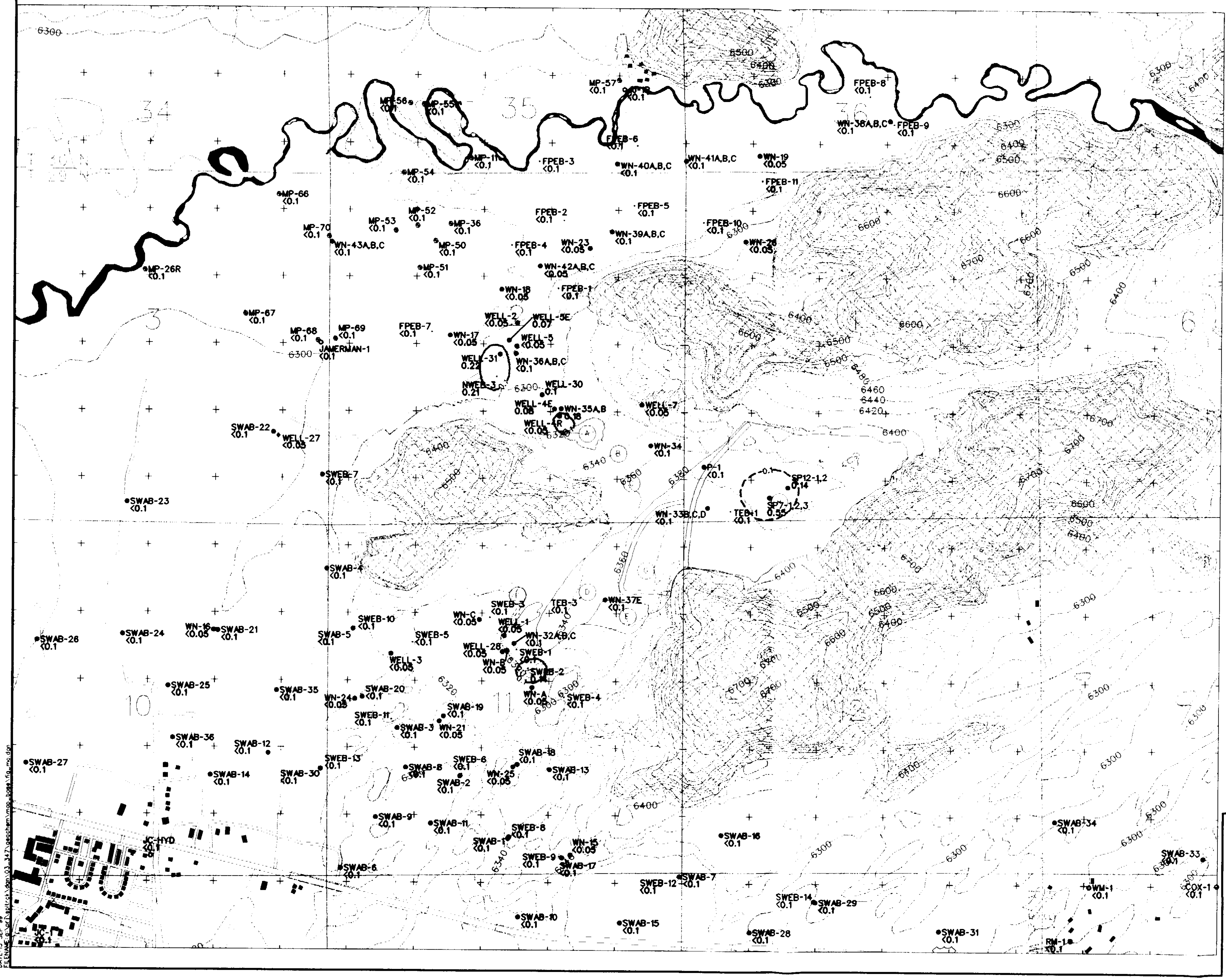



FIGURE 12
GROUND WATER MANGANESE CONCENTRATIONS, 1996/97, SPLIT ROCK SITE




FORMER SITE FEATURES

- NORTHWEST VALLEY SEEPAGE POND
- ORE PAD
- SPLIT ROCK MILL COMPLEX
- ALTERNATE TAILING IMPOUNDMENT
- WASTE TRENCH AREA
- SEWAGE LAGOON
- OLD TAILING IMPOUNDMENT
- MAIN TAILING IMPOUNDMENT
- 1988 FACILITIES DELINEATION (SOURCE: WNI, 1987, REVISION #1 TO SPLIT ROCK SITE RECLAMATION PLAN, FIG A-1)

LEGEND

- MONITORING WELLS
- EXPLORATION BORINGS
- MINI-PIEZOMETERS
- TOWNSITE AND PRIVATE WELLS
- WNI DRINKING WATER WELLS
- SWAB-8 <0.05 SAMPLE LOCATION ID CONCENTRATION (mg/L)
- 0.001 J POSTED VALUE IS AN ESTIMATED CONCENTRATION
- <0.001 NOT DETECTED AT THE POSTED QUANTITATION LIMIT
- <0.001 J NOT DETECTED AT THE POSTED ESTIMATED QUANTITATION LIMIT
- GRANITE OUTCROP AREA
- EXISTING TOPOGRAPHY
- MOLYBDENUM GROUND WATER CONCENTRATION CONTOURS

NOTE:
VALUE POSTED AT WELL SYMBOL REPRESENTS THE MAXIMUM DISSOLVED CONCENTRATION DETECTED AT ANY DEPTH (OR IN ANY WELL OF A WELL CLUSTER) DURING SAMPLING CONDUCTED BETWEEN FEBRUARY 1996 AND JUNE 1997. SEE CROSS SECTIONS (IF APPROPRIATE) FOR VERTICAL DISTRIBUTION OF CONSTITUENTS.

BACKGROUND LIMITS:

SPLIT ROCK FORMATION GW: 0.1 mg/L
FLOODPLAIN ALLUVIUM GW: 0.1 mg/L

N

SCALE IN FEET

1500 0 3000

FIGURE 13
GROUND WATER MOLYBDENUM CONCENTRATIONS, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER

Project: 03-347
File: FIG_MO
Query: MO_GEOCHEM

TIME: 14:22:10
DATE: 15 SEP 99

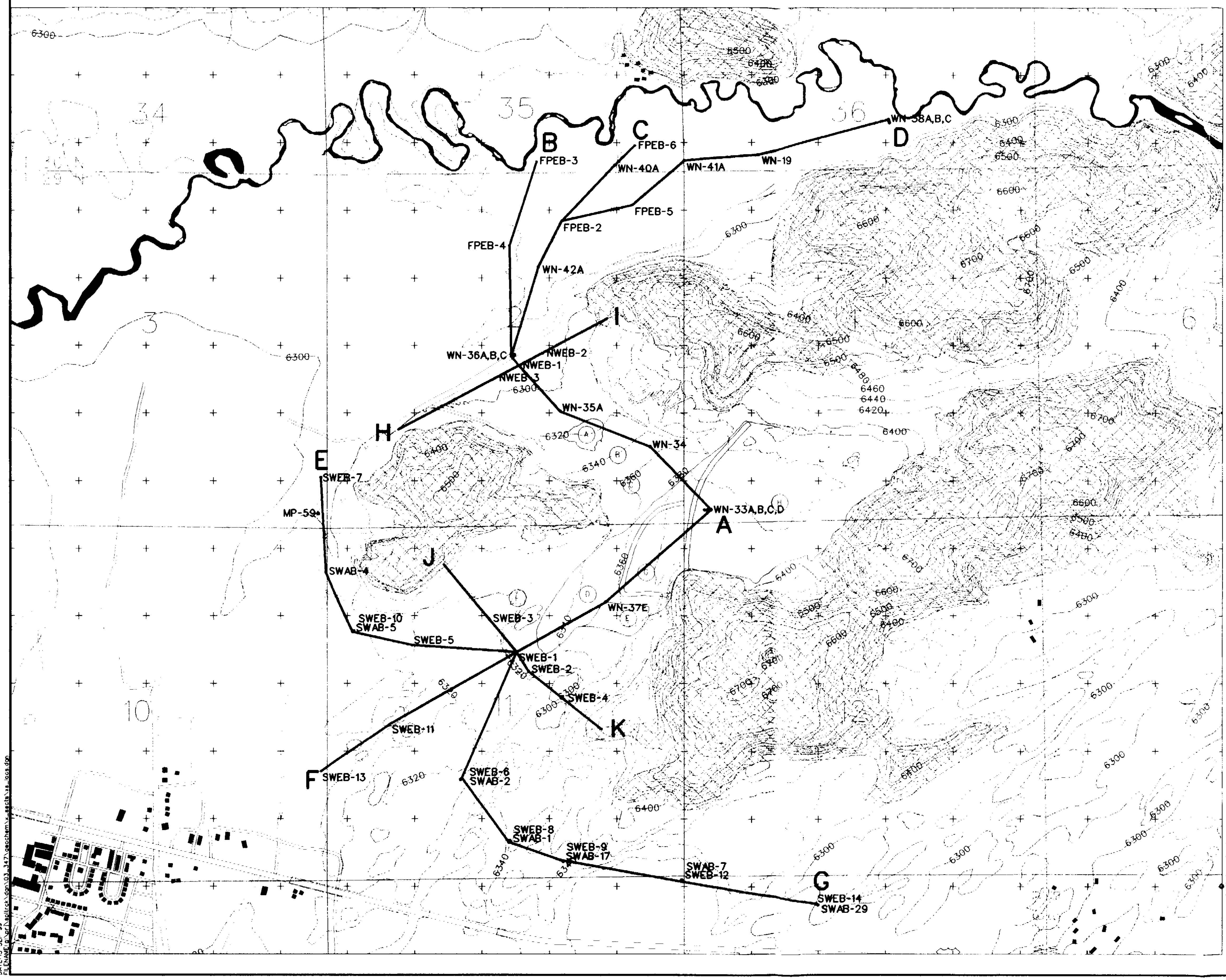



FIGURE 14
GEOCHEMISTRY CROSS SECTION LOCATIONS, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER

Project: 03-347
File: XS_LOCS
Query: N/A

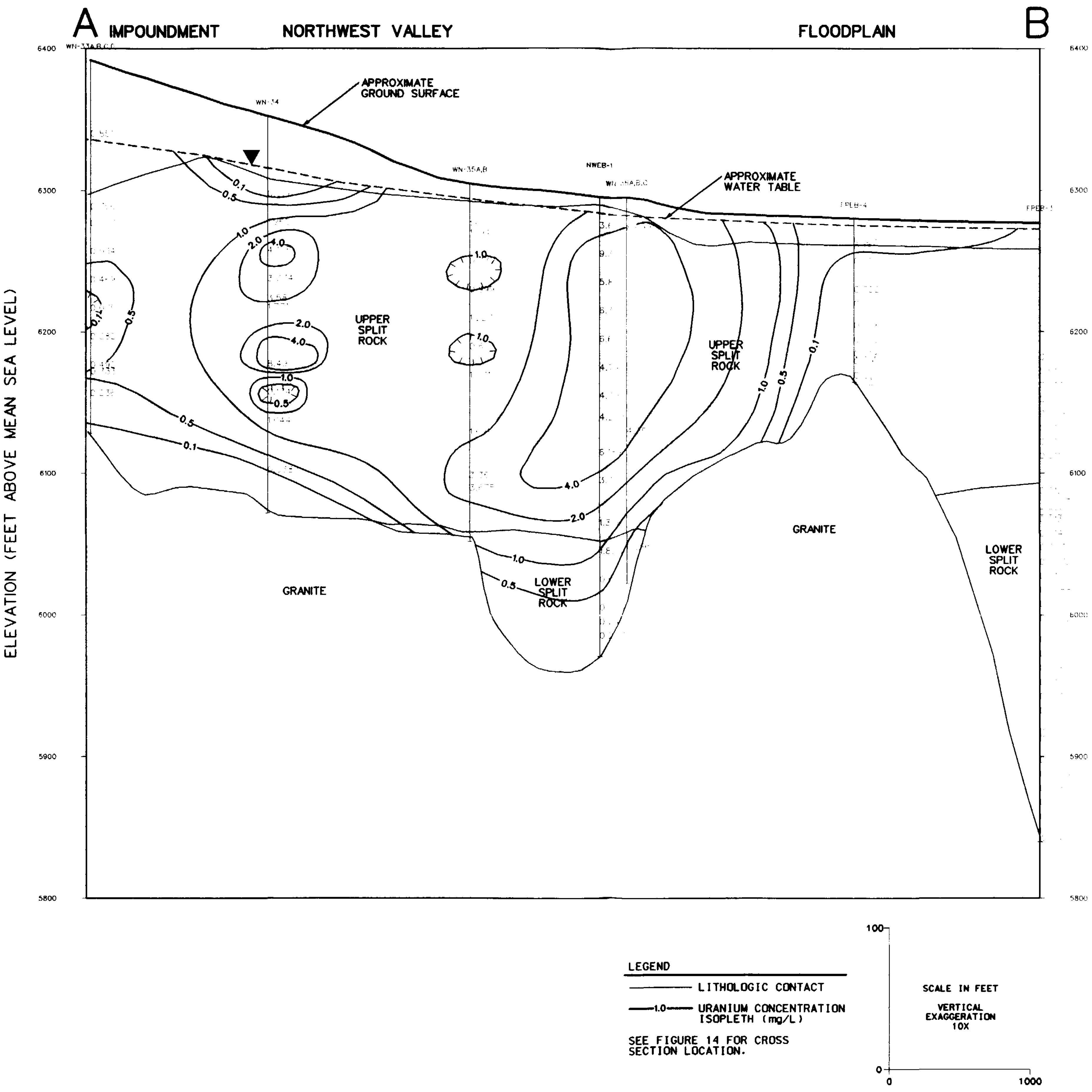
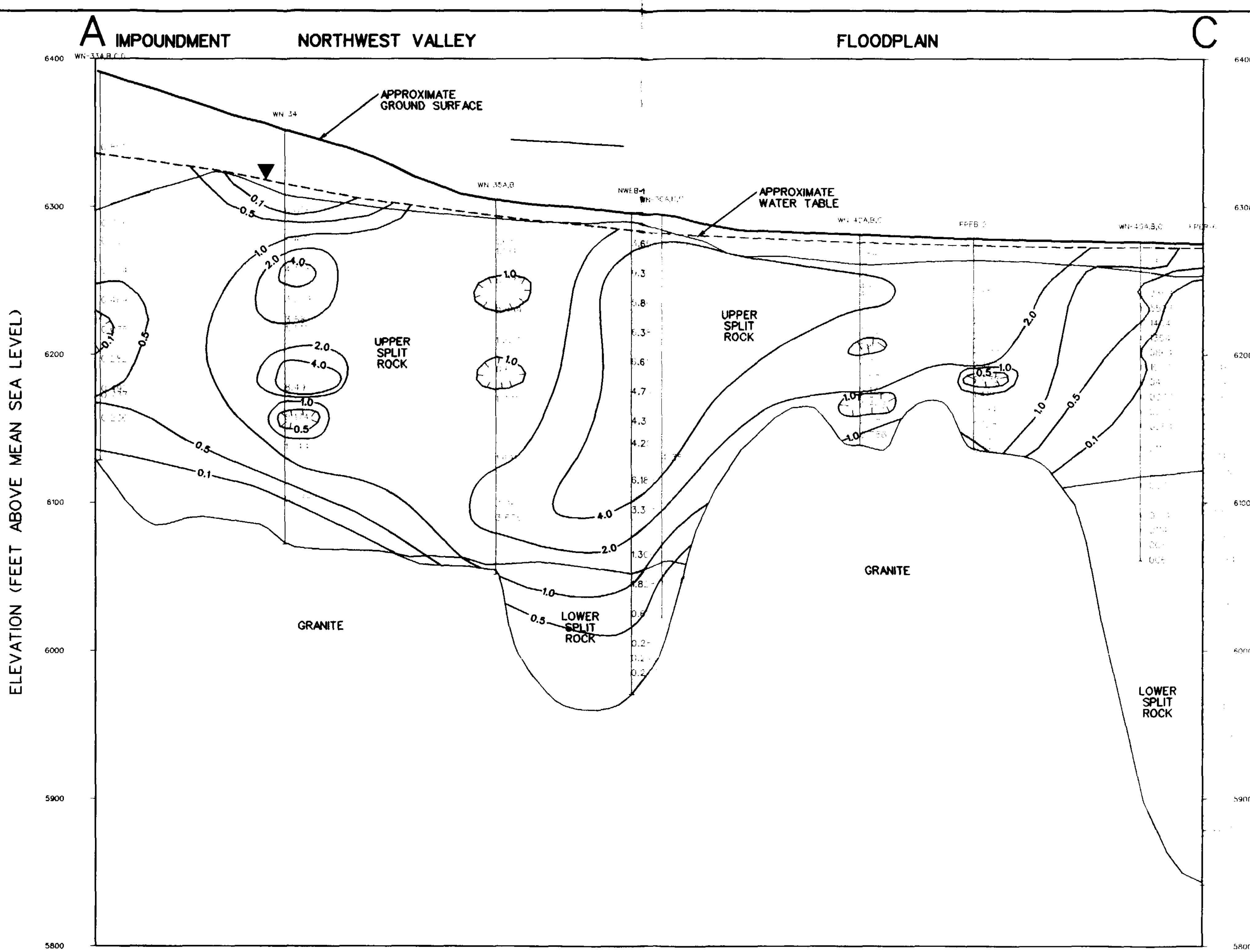



FIGURE 15
GROUND WATER URANIUM CONCENTRATIONS, SECTION AB, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER INCORPORATED

Project: 03-347
File: XS_U_AB
Query:

TIME:14:25:43
DATE:15 SEP 99
FILENAME:g:\pr\splrock\dgn\03_347\geochem\x_sects\xs_u_ab.dgn




LEGEND

LITHOLOGIC CONTACT

1.0 URANIUM CONCENTRATION ISOPLETH (mg/L)

SEE FIGURE 14 FOR CROSS SECTION LOCATION.

SCALE IN FEET

VERTICAL EXAGGERATION 10X

100

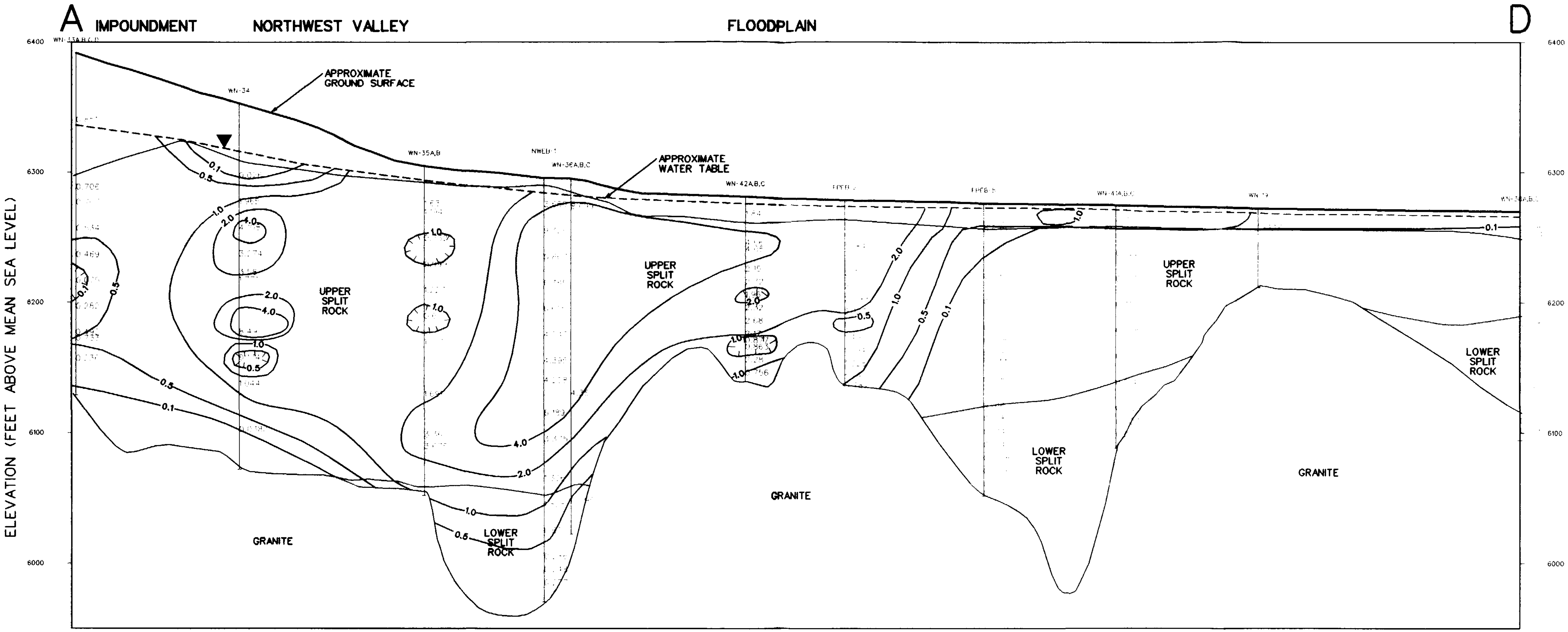
0

0 1000

FIGURE 16
GROUND WATER URANIUM CONCENTRATIONS, SECTION AC, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER INCORPORATED

Project: 03-347
File: XS_U_AC
Query:




LEGEND

LITHOLOGIC CONTACT

—1.0— URANIUM CONCENTRATION ISOPLETH (mg/L)

SEE FIGURE 14 FOR CROSS SECTION LOCATION.

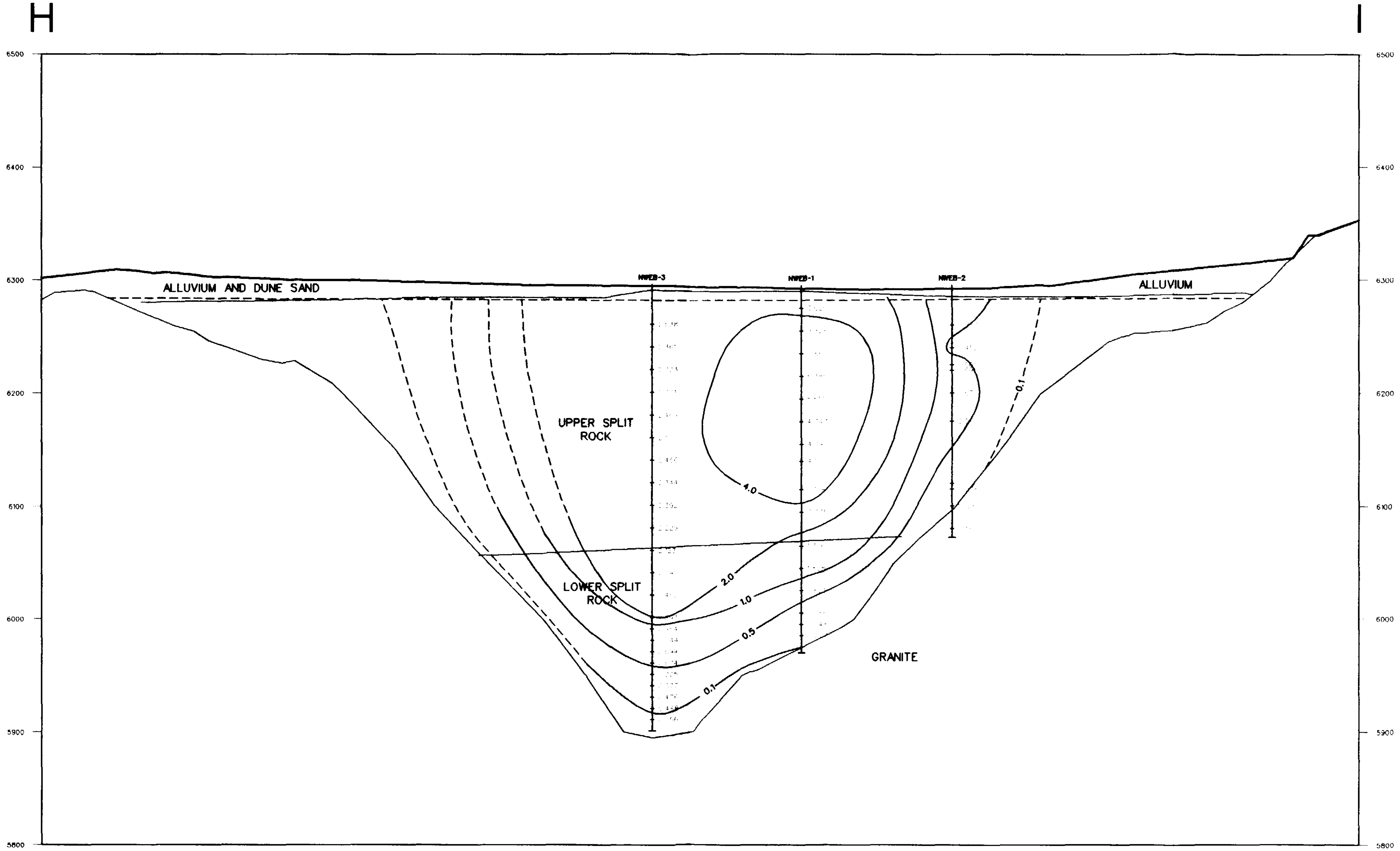
SCALE IN FEET

VERTICAL EXAGGERATION 10X

FIGURE 17
GROUND WATER URANIUM CONCENTRATIONS, SECTION AD, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER INCORPORATED

Project: 03-347
File: XS_U_AD
Query:




LEGEND

LITHOLOGIC CONTACT

1.0 URANIUM CONCENTRATION ISOPLETH (mg/L)

SEE FIGURE 14 FOR CROSS SECTION LOCATION.

SCALE IN FEET

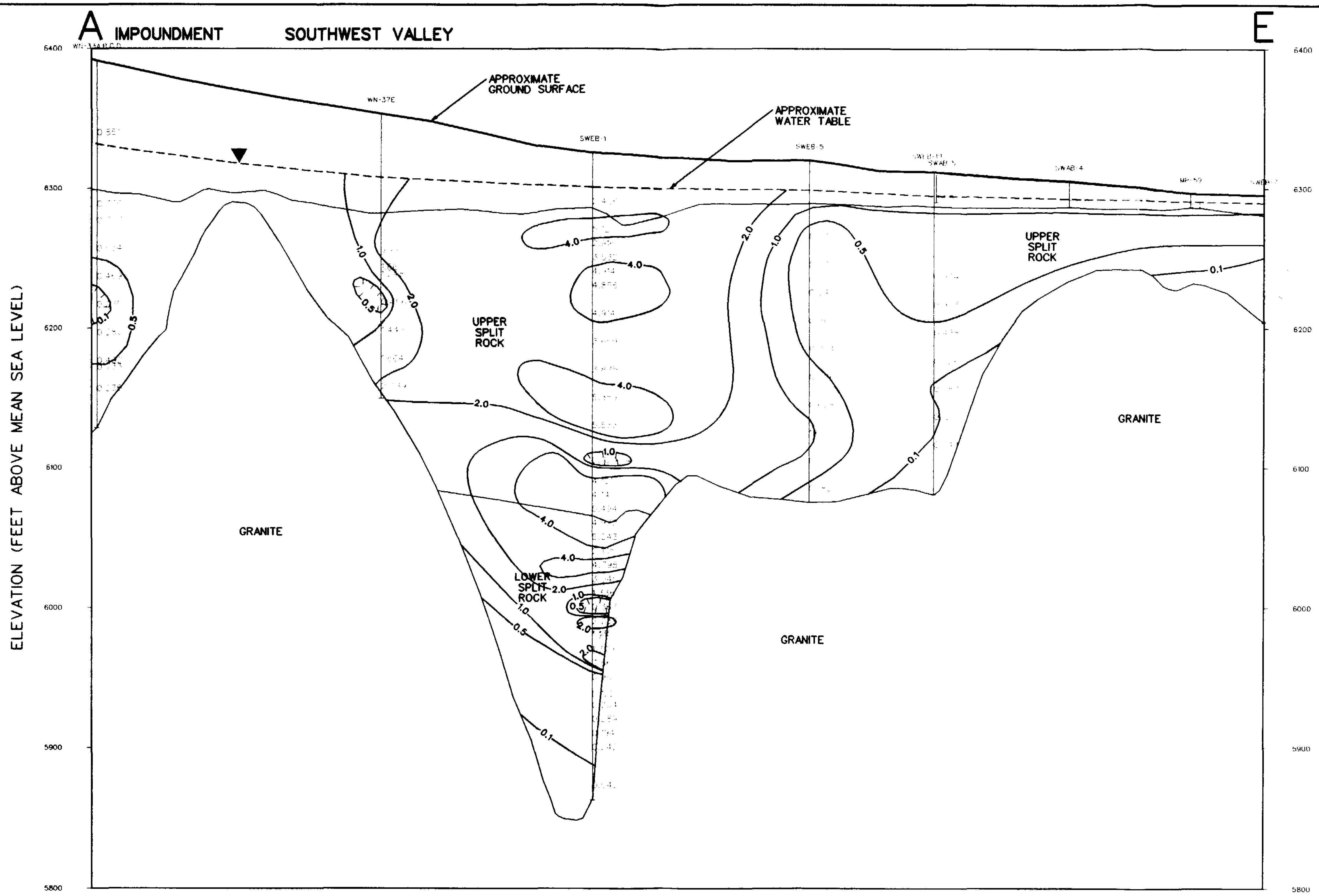
0 100 300

VERTICAL EXAGGERATION 3X

FIGURE 18
GROUND WATER URANIUM CONCENTRATIONS, SECTION HI, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER

Project: 03-347/008
File: XS_U_HI
Query:




**LEGEND**

—— LITHOLOGIC CONTACT

—1.0— URANIUM CONCENTRATION ISOPLETH (mg/L)

SEE FIGURE 14 FOR CROSS SECTION LOCATION.

SCALE IN FEET

VERTICAL EXAGGERATION 10X

100 / 0 / 0 / 1000

FIGURE 19
GROUND WATER URANIUM CONCENTRATIONS, SECTION AE, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER INCORPORATED

Project: 03-347
File: XS_U_AE
Query:

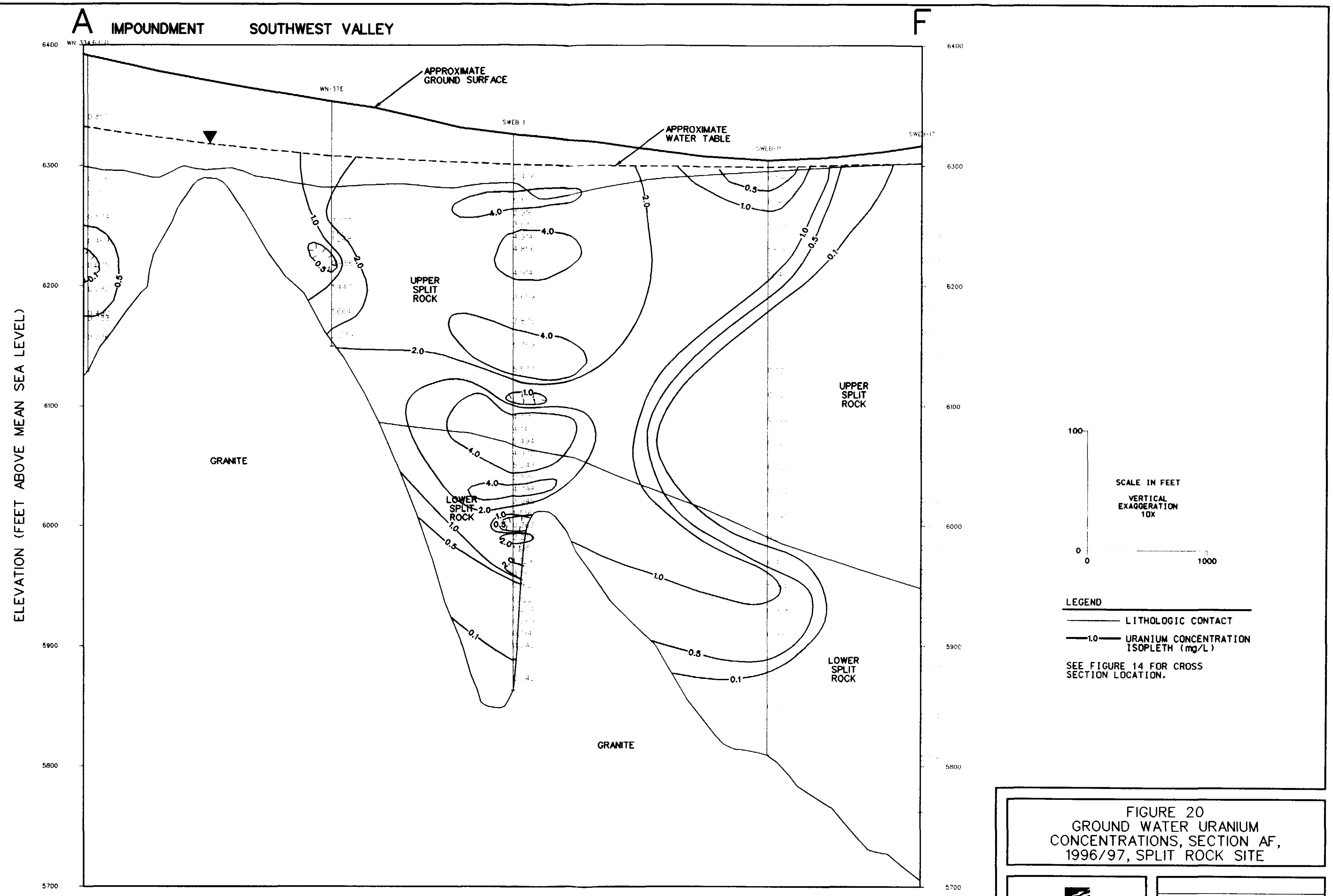
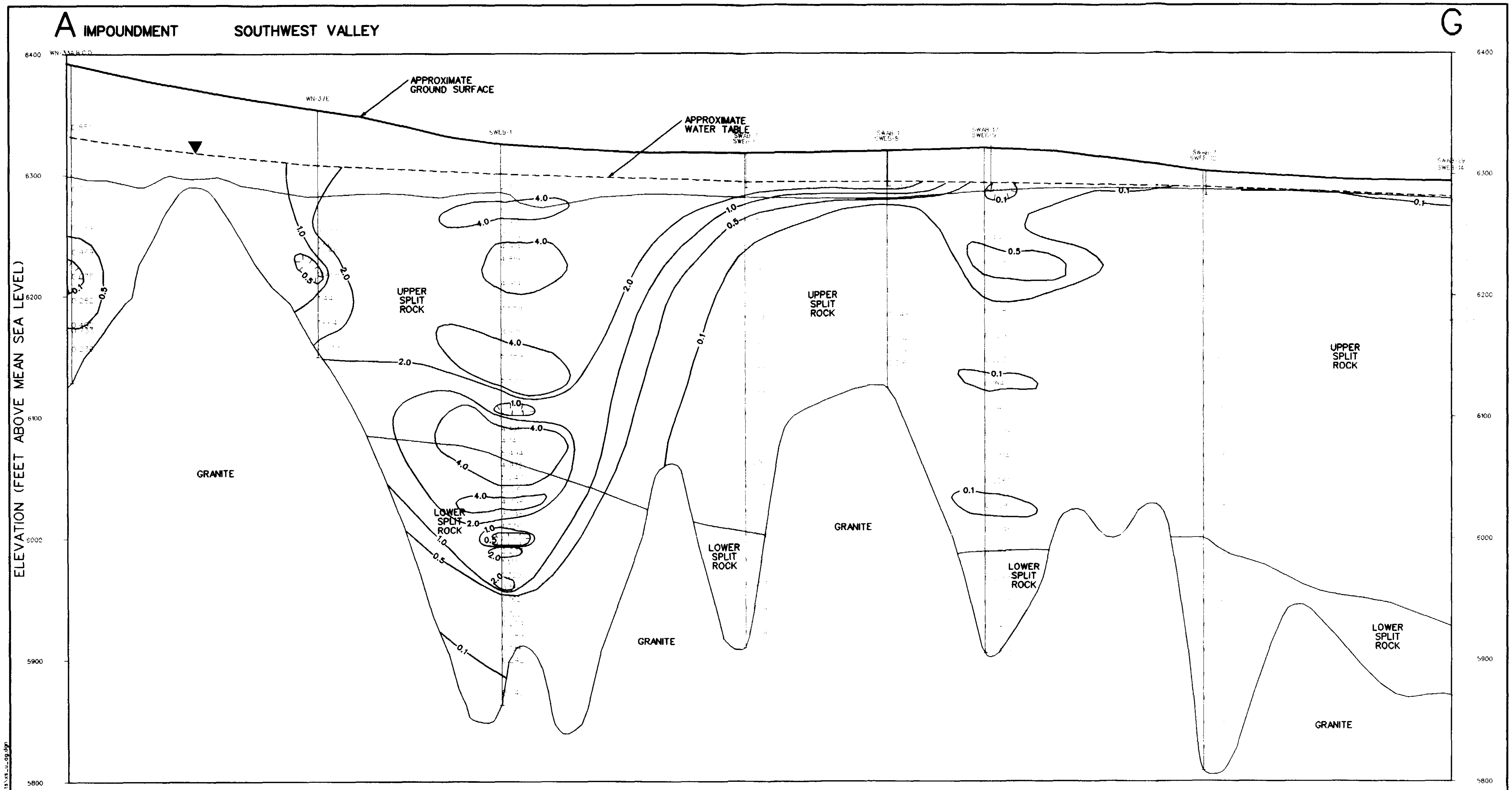



FIGURE 20
GROUND WATER URANIUM CONCENTRATIONS, SECTION AF, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER INCORPORATED

Project: 03-347
File: XS_U_AF
Query:

TIME: 14:31:53
DATE: 15 SEP 99
FILENAME: g:\prj\splitrck\dgn\03_347\geochem\x_sects\xs_u_af.dgn




LEGEND

LITHOLOGIC CONTACT

1.0 URANIUM CONCENTRATION ISOPLETH (mg/L)

SEE FIGURE 14 FOR CROSS SECTION LOCATION.

SCALE IN FEET

VERTICAL EXAGGERATION 10X

0 1000

FIGURE 21
GROUND WATER URANIUM CONCENTRATIONS, SECTION AG, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER INCORPORATED

Project: 03-347
File: XS_U_AG
Query:

TIME:14:32:38
DATE:15 SEP 99
FILENAME:g:\pr\splrck\dgn\03_347\geochem\v_sects\xs_u_ag.dgn

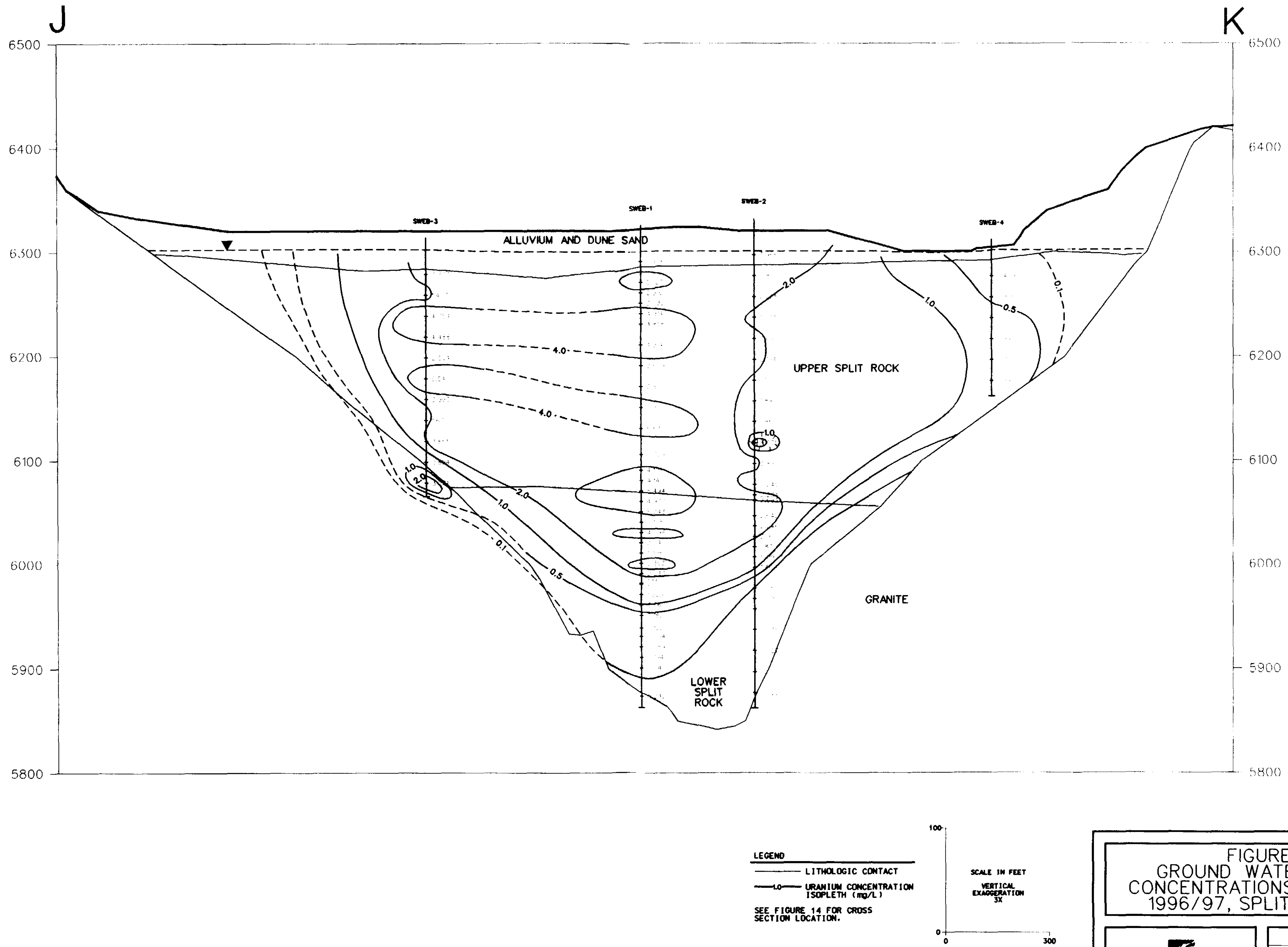
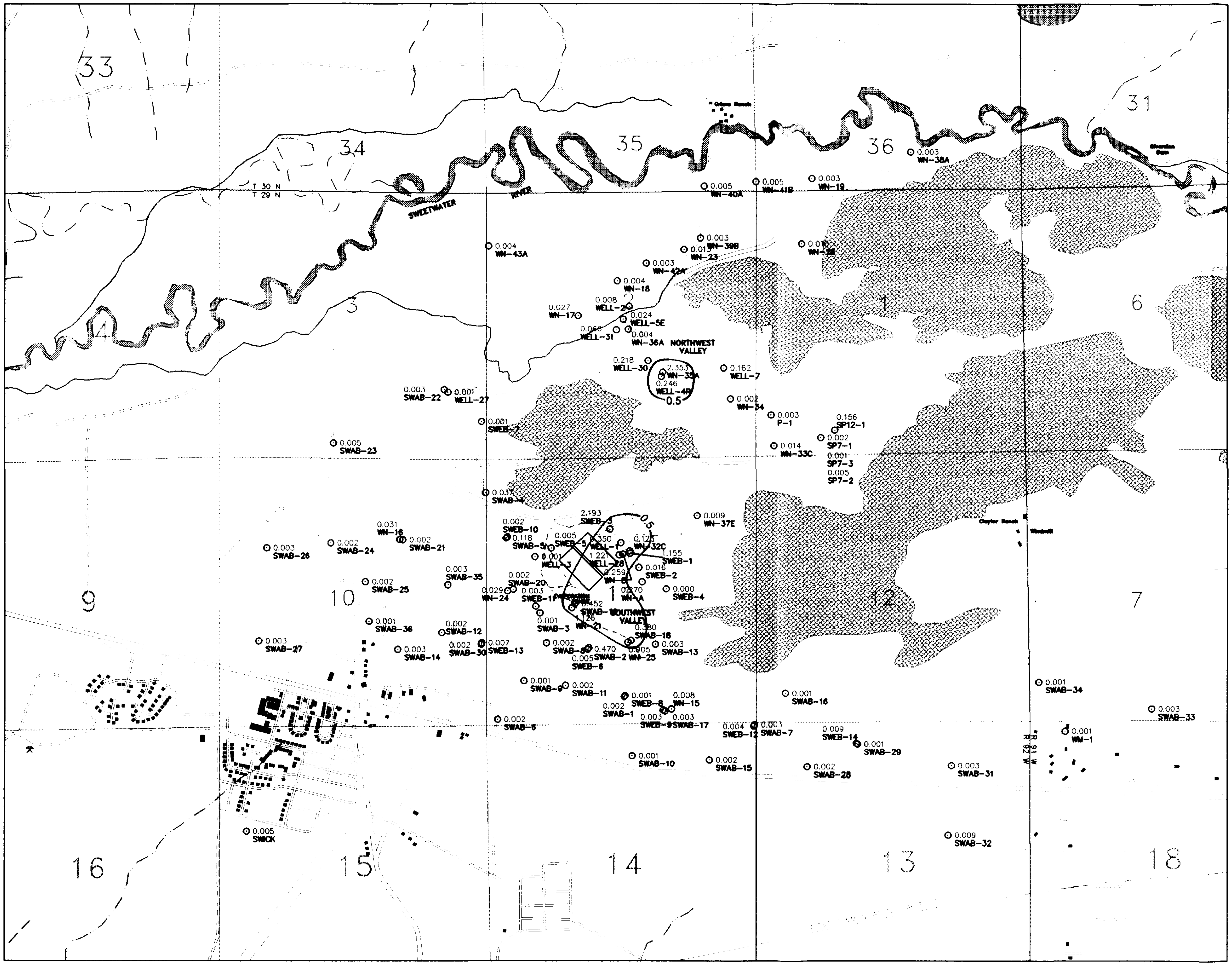



FIGURE 22
GROUND WATER URANIUM CONCENTRATIONS, SECTION JK, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER

Project: 03-347\Task 4
File: XS_U_JK
Query:




LEGEND

—0.5— $NH_3$ CONCENTRATION CONTOUR (mg/L)

NOTE: ALL VALUES SHOWN ARE FOR AMMONIA ($NH_3$) BASED ON $NH_4$-N DATA, CONVERTED USING EQUATION pH = pK + Log ($NH_3$/$NH_4$+) WITH pK = 9.3

SCALE IN FEET

2000 0 4000

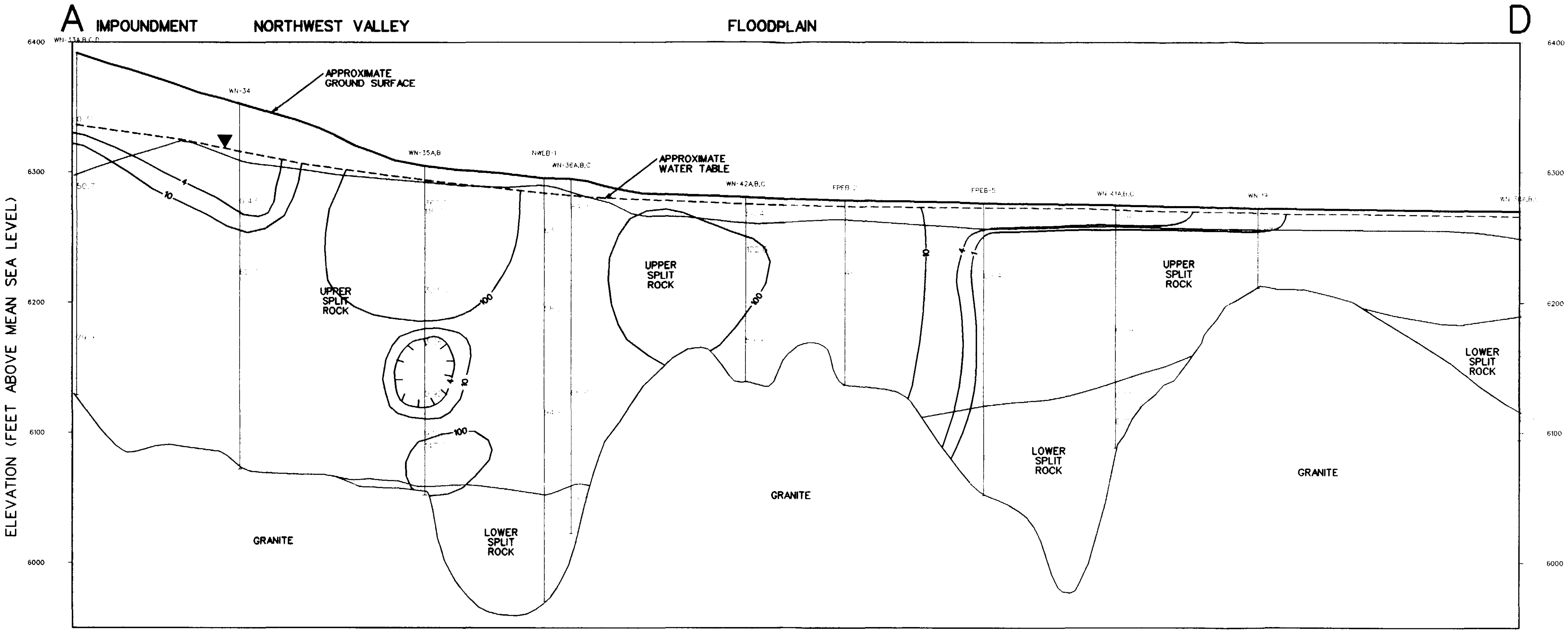
# FIGURE 26
# CALCULATED GROUND WATER $NH_3$ CONCENTRATIONS,1996/1997

SHEPHERD MILLER

Project: 03-347/TASK8

File: NH4-CONT.DWG

Filename: E:\03-347\TASK8\NH4-CONT.dwg
Date: 07/28/1999
Time: 10:16:24.35




LEGEND

—— LITHOLOGIC CONTACT

—1.0— NITRATE + NITRATE CONCENTRATION ISOPLETH (mg/L)

SEE FIGURE 14 FOR CROSS SECTION LOCATION.

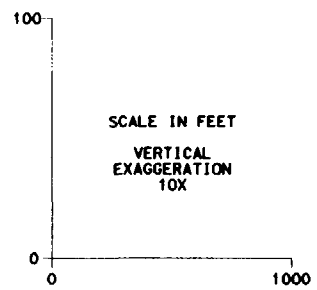
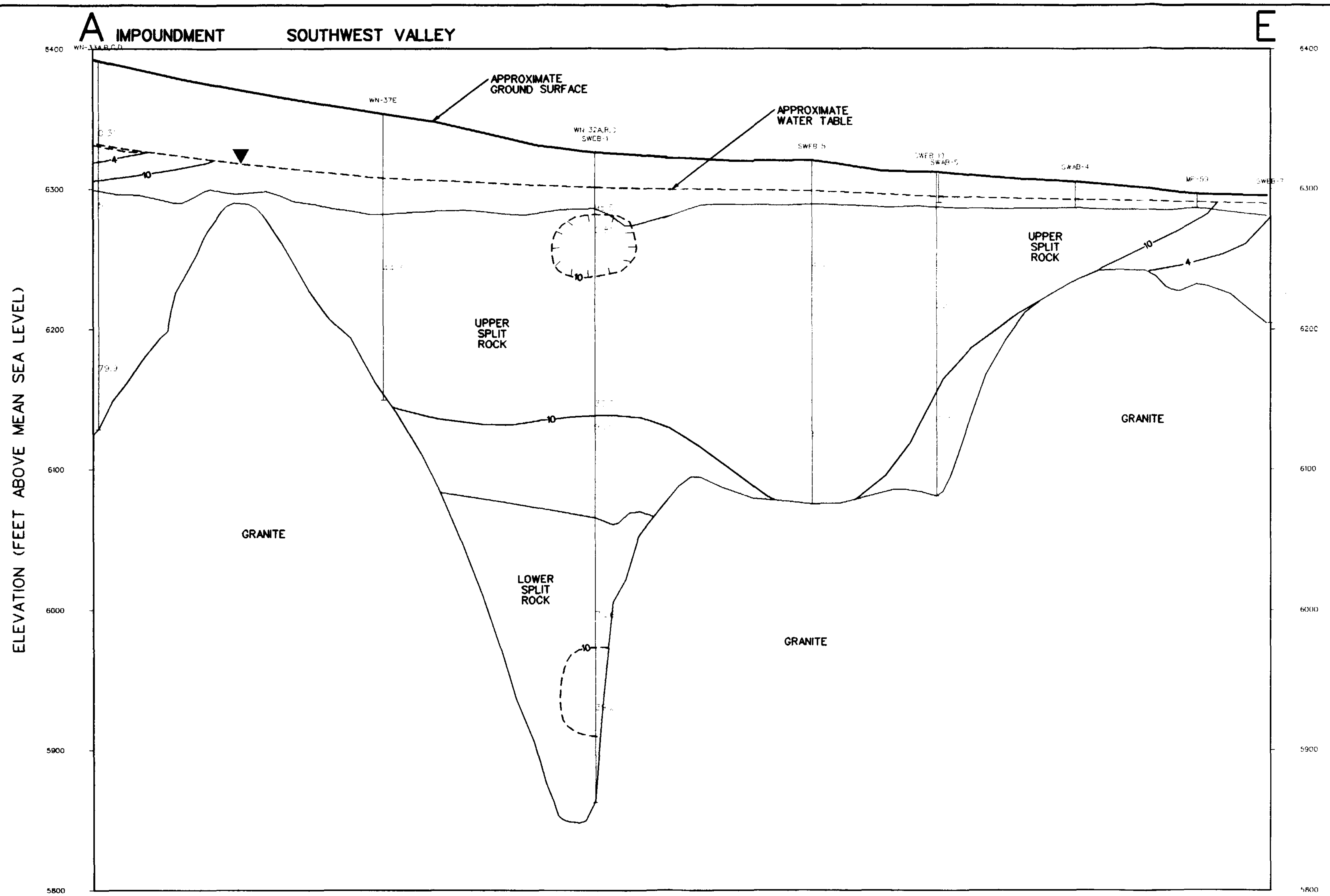



FIGURE 27
GROUND WATER $NO_3+NO_2$ CONCENTRATIONS, SECTION AD, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER INCORPORATED

Project: 03-347
File: XS_NO_AD
Query:

TIME: 14:34:54
DATE: 15 SEP 99
FILENAME: g:\pr\splrck\dgn\03_347\geochem\x_sects\xs_no_ad.dgn




**LEGEND**

—— LITHOLOGIC CONTACT

—1.0— NITRATE + NITRATE CONCENTRATION ISOPLETH (mg/L)

SEE FIGURE 14 FOR CROSS SECTION LOCATION.

SCALE IN FEET

VERTICAL EXAGGERATION 10X

100 | 0 | 0 | 1000

FIGURE 28
GROUND WATER $NO_3$+$NO_2$ CONCENTRATIONS, SECTION AE, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER INCORPORATED

Project: 03-347
File: XS_NO_AE
Query:

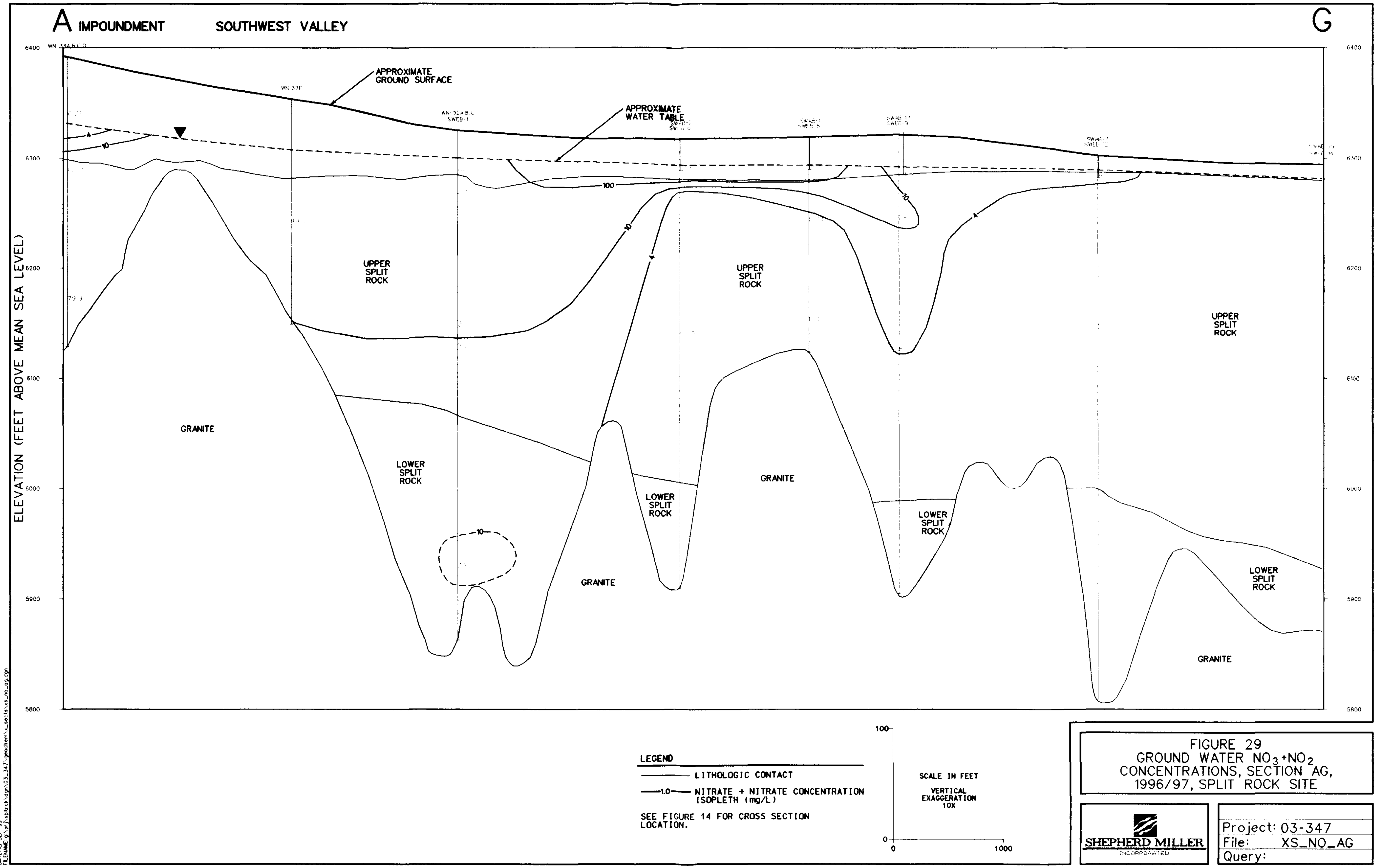
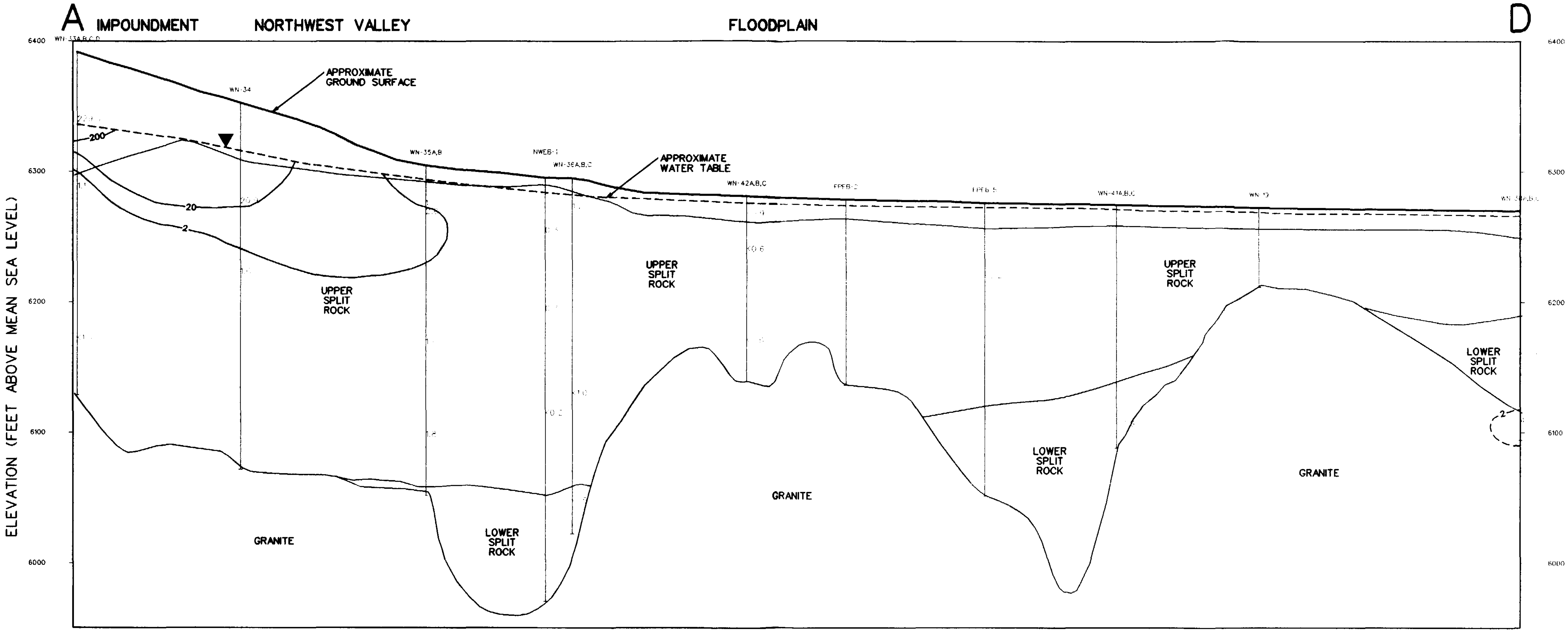



FIGURE 29
GROUND WATER $NO_3$+$NO_2$ CONCENTRATIONS, SECTION AG, 1996/97, SPLIT ROCK SITE




LEGEND

LITHOLOGIC CONTACT

—1.0— RADIUM-226 ACTIVITY ISOPLETH (pCi/L)

SEE FIGURE 14 FOR CROSS SECTION LOCATION.

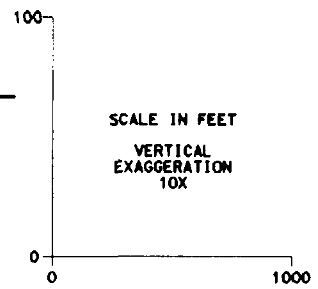



FIGURE 30
GROUND WATER Ra-226 ACTIVITIES, SECTION AD, 1996/97, SPLIT ROCK SITE

SHEPHERD MILLER INCORPORATED

Project: 03-347
File: XS_RA226_AD
Query:

TIME: 14:39:04
DATE: 15 SEP 99
FILENAME: g:\prj\splrck\dgn\03_347\geochem\x_sects\xs_ra226_ad.dgn

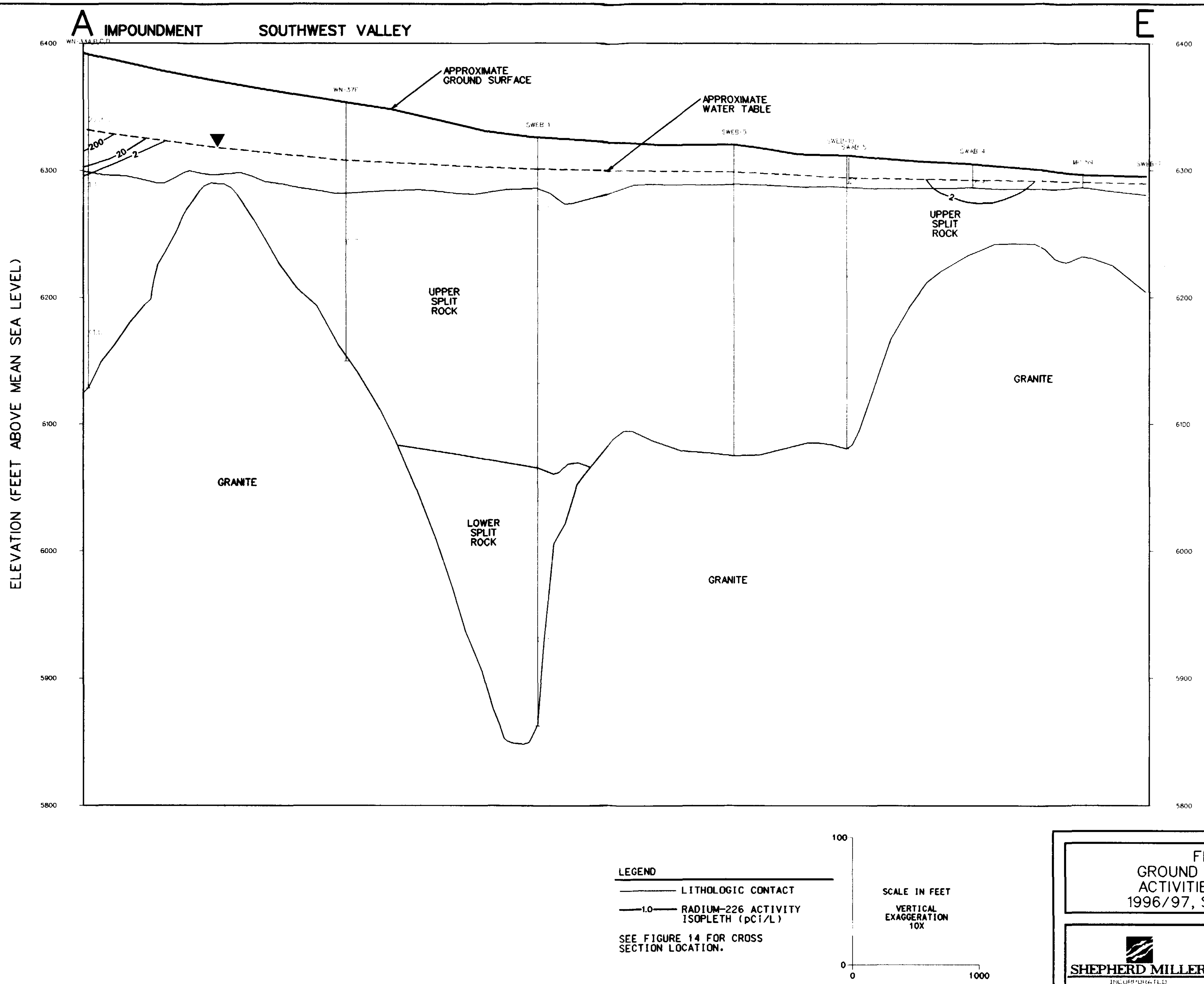
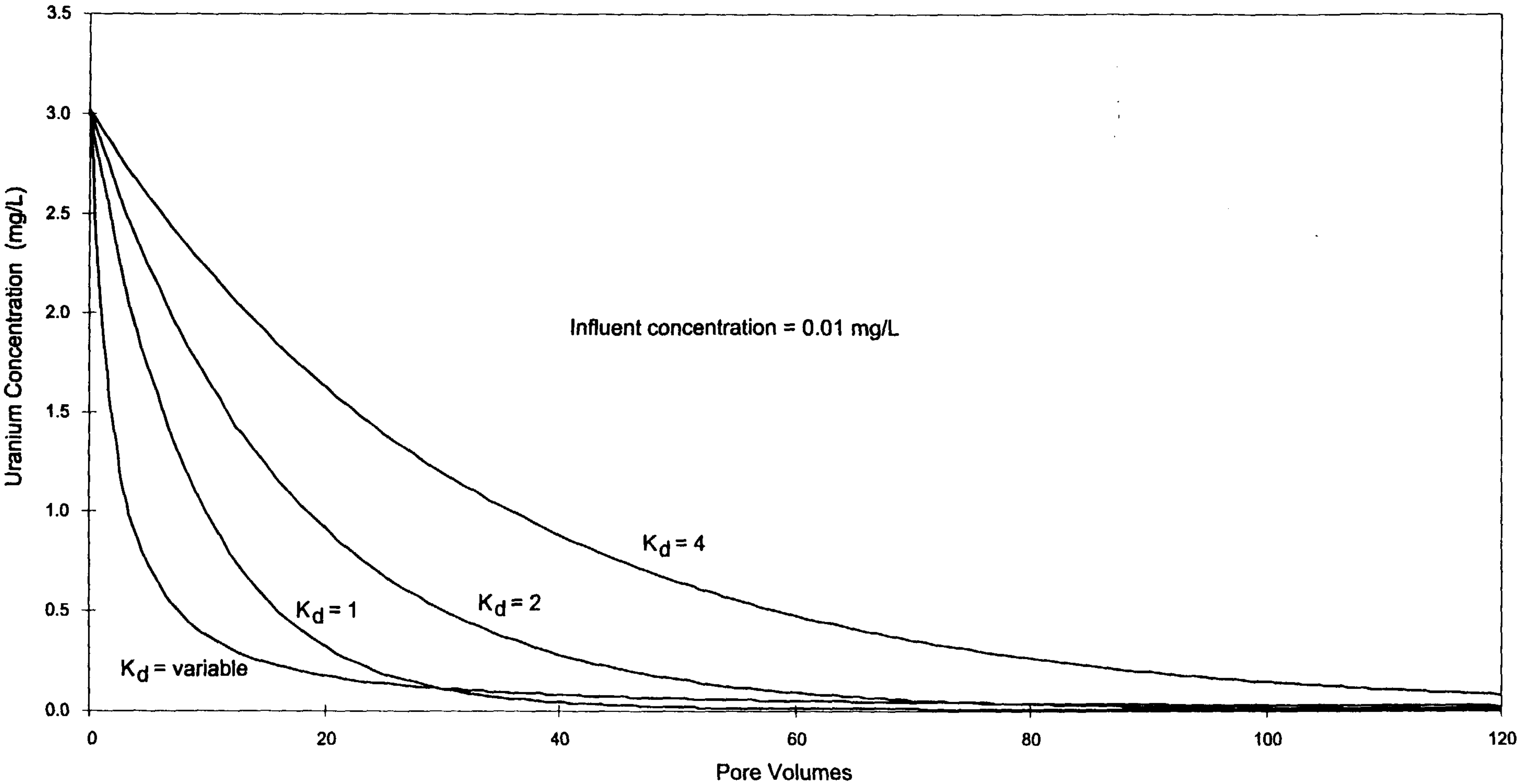



FIGURE 31
GROUND WATER Ra-226
ACTIVITIES, SECTION AE,
1996/97, SPLIT ROCK SITE

SHEPHERD MILLER INCORPORATED

Project: 03-347
File: XS_RA226_AE
Query:

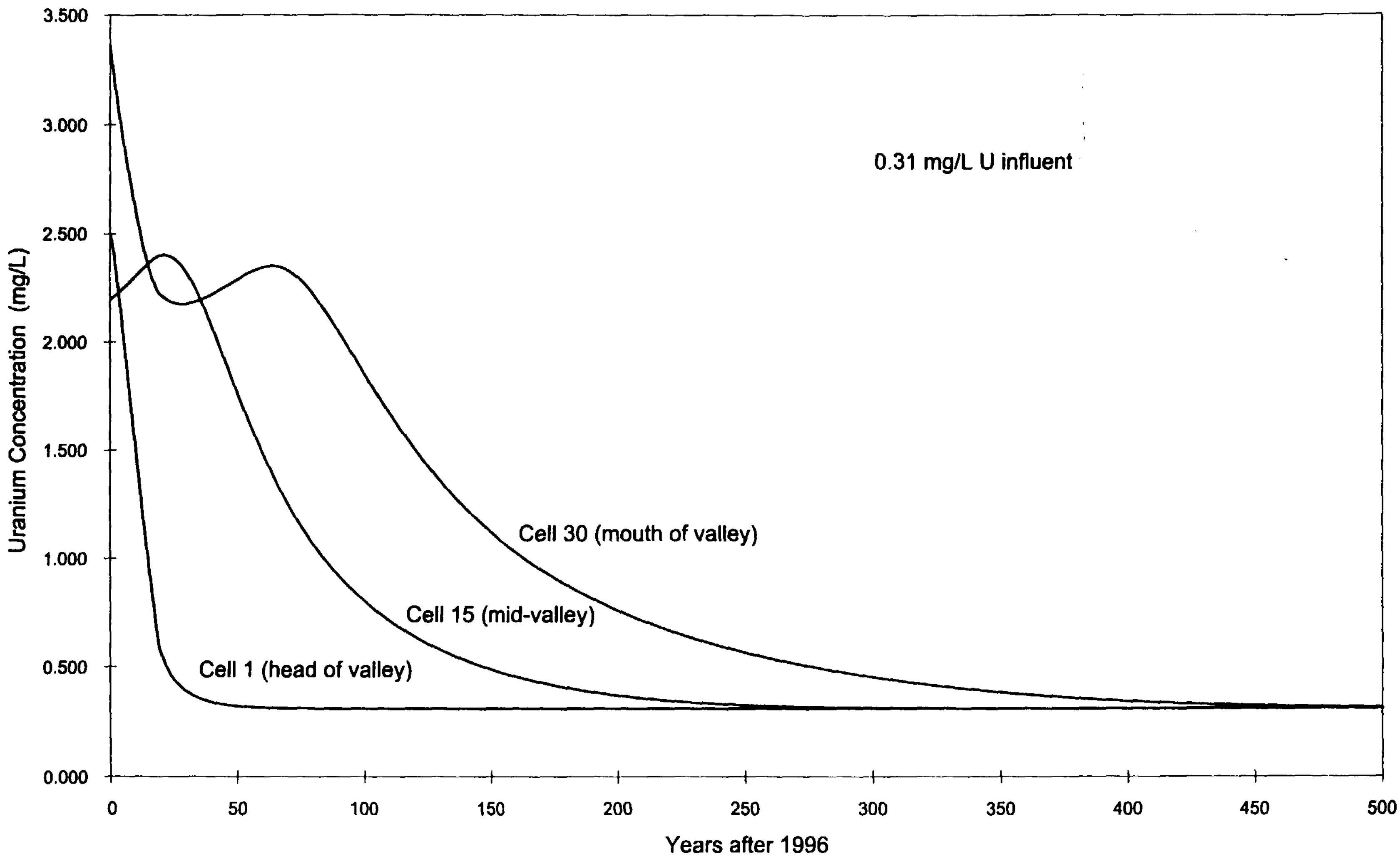
TIME:14:40:00
DATE:15 SEP 99




SHEPHERD MILLER
INCORPORATED

FIGURE 23
COMPARISON OF PREDICTIONS
USING FIXED AND VARIABLE $K_d$s

| | |
|---|---|
| Project: | 03-347\TASK8 |
| File: | FIG-F618.dwg |

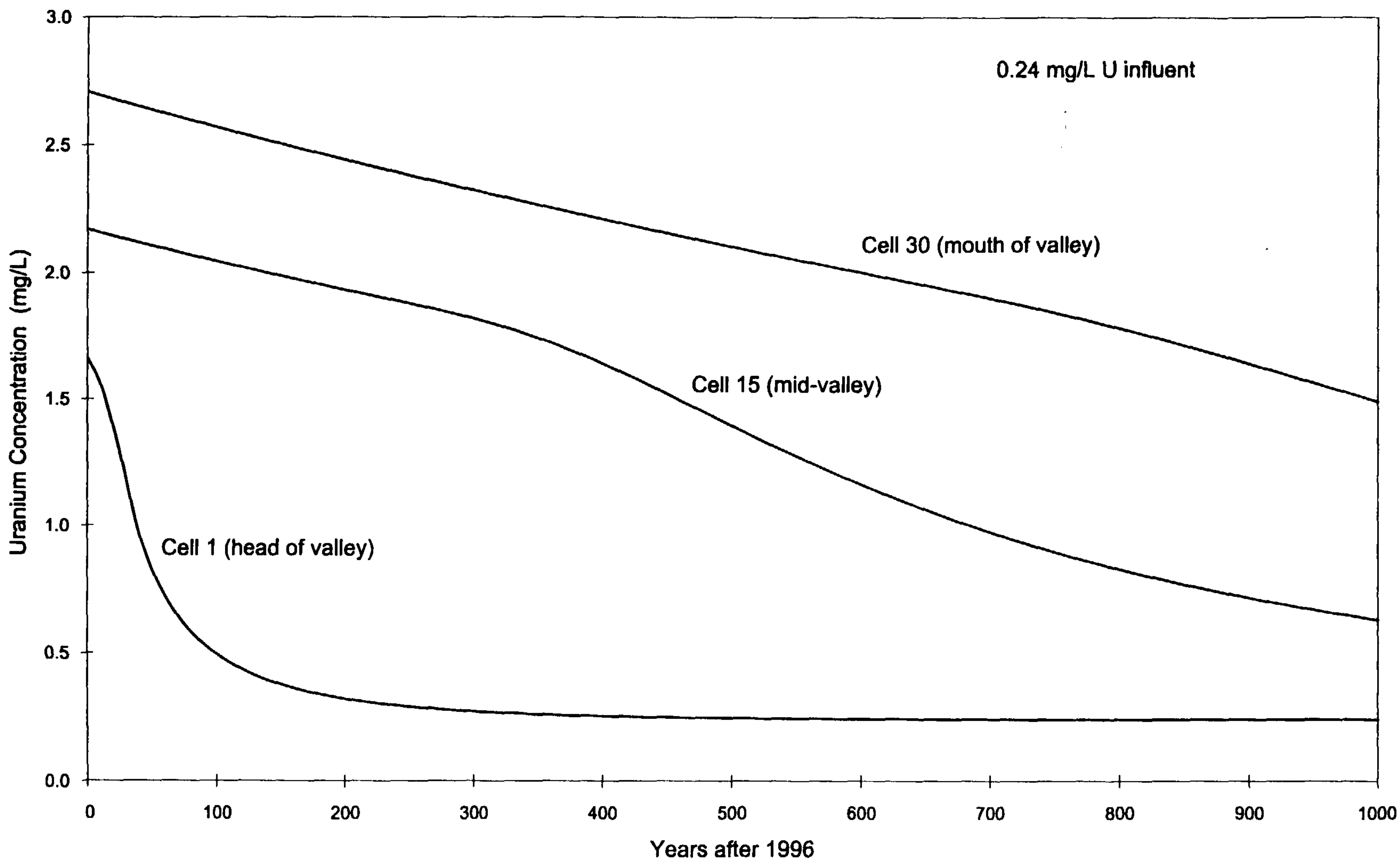



SHEPHERD MILLER INCORPORATED

FIGURE 24
FUTURE URANIUM CONCENTRATIONS IN THE NORTHWEST VALLEY

Project: 03-347\TASK8

File: FIG-F619.dwg




SHEPHERD MILLER INCORPORATED

FIGURE 25
FUTURE URANIUM CONCENTRATIONS IN THE SOUTHWEST VALLEY

| | |
|---|---|
| Project: | 03-347\TASK8 |
| File: | FIG-F620.dwg |