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Received
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Division of
Radiation Control

March 29, 2012

Mr Rusty Lundberg, Executive Secretary
Utah Radiation Control Board
Utah Department of Environmental Quality
PO Box 144810
Salt Lake City, UT 84114-4810

RE Two Year Extension of Radioactive Materials License UT 0900480 for the Shootaring Canyon Mill Submittal of Additional Information

DRC-2012-001447

Dear Mr Lundberg

Uranium One is submitting the following information as requested as part of the granting of a two year extension to Radioactive Material License UT 0900480 Please find the attached information as requested by your letter of October 13, 2011

1 An updated Tailings Reclamation and Decommissioning Plan Included is an itemized cost estimate for decommissioning of the Shootaring Canyon Mill facility at current status for unrestricted release

2 Electronic copy of Standard Operating Procedures

3 Electronic copy of training records for mill personnel and CRSO

Uranium One has updated the Tailings Reclamation and Decommissioning Plan for the Shootaring Canyon Uranium Project to reflect current ownership conditions at the facility It is not being submitted for review and approval purposes as this document represents the current approved site Reclamation Plan for the Shootaring Canyon Mill

Uranium One understands that the cost estimate for decommissioning of the Shootaring Canyon Mill for Unrestricted Use is for information purposes only and is not intended to modify current surety estimates for onsite reclamation The current approved Reclamation Plan for the Shootaing Canyon Mill is for disposal of the tailings, contaminated soils and equipment at the existing Shootaring Canyon Mill tailings facility

If you have any questions with regards to the information provided please do not hesitate to contact me by email at norman schwab@uranium1.com or call at (303) 325-2379

Regards

Norman Schwab
Vice President Mining
Uranium One Americas, Inc

Uranium One America's, Inc
A Member of the Uranium One Inc Group of Companies
tel +1 307-234-8235 • fax +1 303-325-0110
907 N Poplar • Suite 260
Casper • WY 82601
www uranium1 com

Tailings Reclamation and Decommissioning Plan for Shootaring Canyon Uranium Project Garfield County, Utah

SUA-1371
UT 0900480

October, 2002
Revised February, 2003
Revised April, 2003
Revised July, 2003
Revised September, 2003
Revised November, 2003

Uranium One Americas, Inc.
907 N. Poplar Street, Suite, 260
Casper, Wyoming 82601

BY:
HYDRO-ENGINEERING, L.L.C.
ENVIRONMENTAL RESTORATION GROUP, INC.

Professional Engineer
Thomas G. Michel
11/26/2003
364421-2202
State of Utah

Kenneth R. Baker
Kenneth R. Baker, Ph.D.
Health Physicist

George L Hoffman
Hydrologist

Thomas G. Michel
Thomas G. Michel, Ph.D., P.E.
Hydrologist

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PREFACE

This report presents an updated final reclamation and mill decommissioning plan for the Shootaring Canyon mill and tailings. Uranium One Americas, has developed this plan to decommission the mill and complete final reclamation of the tailings. The introduction and site description are presented in Sections 1 and 2 in the report. Information from an additional field investigation is presented in Section 3. The clay cover design is given in Section 5 while the rock protection is presented in Section 6. Sections 8 and 9 present the mill decommissioning and tailings reclamation details respectively. Reclamation schedule is discussed in Section 10. Cost estimates are given in Sections 11 and 12.

Appendices A, B and C in this report present the details of new data obtained on Shootaring site which are discussed primarily in Sections 3 and 5. Appendix D of this report presents the surface water modeling which is used with Section 6. Appendices E through I and Section 8 present details on the mill decommissioning. Appendix J presents modeling results for infiltration through the clay cap. Page, figure and table numbers are sequenced by the section number. Tables are located after their initial reference while all figures follow all text in their respective section.

1.0 INTRODUCTION & SUMMARY

1.1 Introduction

Uranium One Americas, Inc. is planning to decommission its uranium mill, referred to as the Shootaring Canyon Uranium Project. The mill is licensed to operate under Utah Division of Radiation Control, Radioactive Materials License (RML) UT 0900480. The mill operated for a very limited period of time and the tailings facility contains only 25,000 C.Y. of tailings material. An additional volume of 39,100 (18,907 tons Hanksville and 26,500 C.Y. Hydro-Jet) C.Y. of 11.e(2) material exist in the east and north dikes from the cleanup of the Hanksville buying station and the Hydro-Jet plant. Interim ·cover placed over the tailings is 39,310 C. Y. An additional 114,000 C.Y. of contaminated materials are planned to be added to the tailings cell.

The site is located in a sparsely populated area of Garfield County, southeastern Utah, approximately 50 miles south of Hanksville, Utah, 14 miles north of Bullfrog Basin Marina, and 2 miles west of Utah State Highway 276 (see Figure 1-1). A small town, Ticaboo, is located 2.6 miles south of the site.

This reclamation plan has been prepared according to 10 CFR Part 40, Appendix A and the guidance in the NRC Standard Review Plan (NUREG-1620). The goal is to restore lands disturbed by project activities (except for the tailings cell) consistent with past and present uses of the area. It should be noted that this area, and southern Utah in general, are considered very unproductive with little native plant growth due to soil and climate characteristics. The low average annual precipitation of 7 inches (18 cm) frequent droughts; extreme temperatures; high wind erosion; and a loose, and undifferentiated soil profile with poor moisture-holding capacity and little organic content are a few of those characteristics.

This plan presents the current condition, reclamation goals and activities, and estimated costs and schedule for reclaiming Uranium One Americas' mill site and tailings cell.

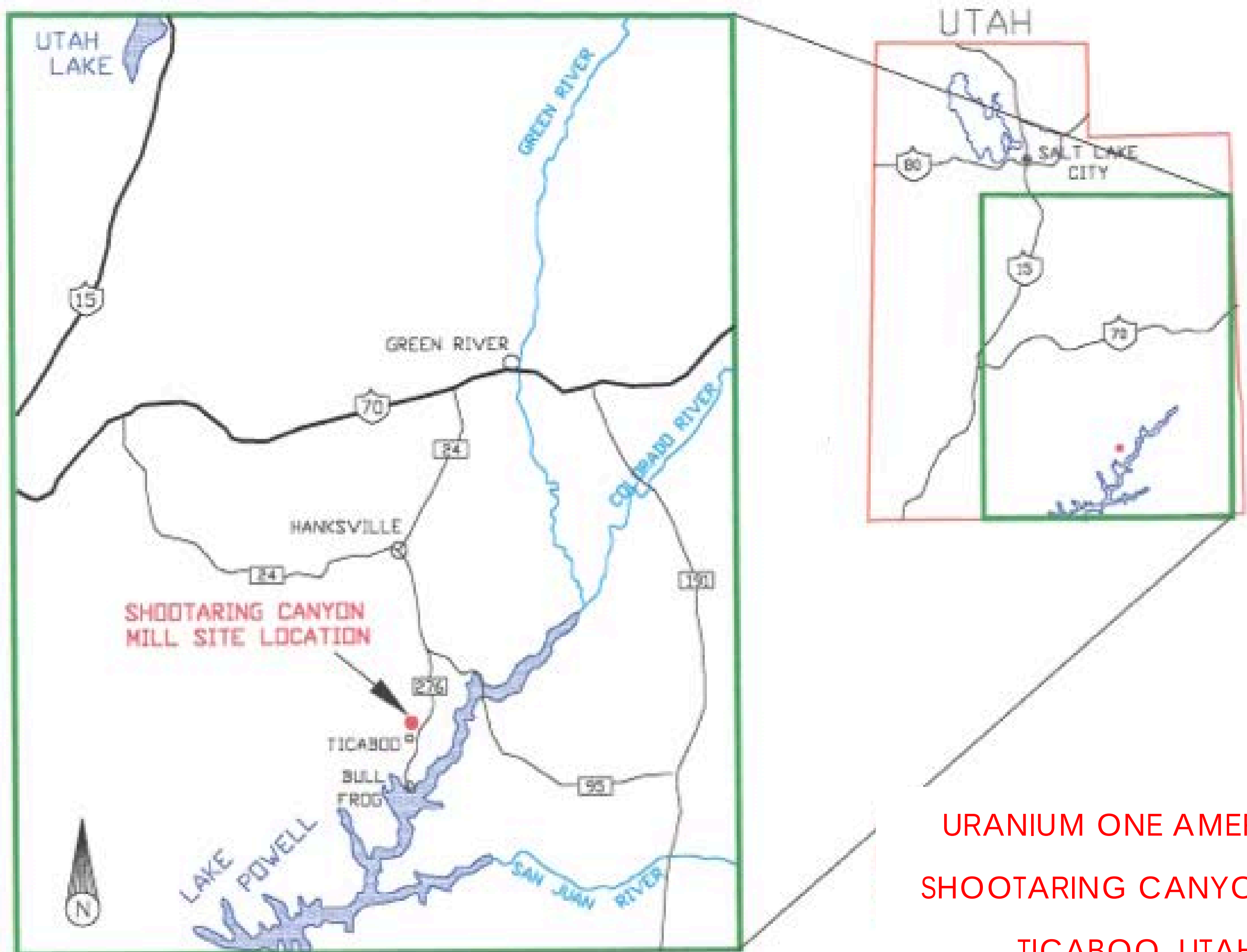
1.2 Summary

This report presents the final mill decommissioning and tailings reclamation for the Shootaring Canyon tailings site. The Shootaring Canyon mill contains contamination within the mill and, in a few locations, in the soil adjacent to the mill that require cleanup. The ore stockpiles adjacent to the mill are the largest volume of material that is required to be placed in the tailings cell. Ore also exists on the top of the cross valley berm and ll.e(2) material exists in the east and north dikes adjacent to the existing tailings cell. The remaining area requiring cleanup is on the upstream side of the Shootaring Dam where solution from the tailings cell spilled and ponded in this area. Additional soil needs to be picked up in this area due to an incomplete cleanup after all of the solution was pumped back to the tailings cell.

An additional field investigation was conducted to define the estimated volumes for these cleanups for design purposes in the tailings cell. The material in the channel cut on the east side of the tailings cell is proposed for use as interim cover. The clay in the core of the Shootaring Dam is proposed for the radon/infiltration barrier on the tailings cell. Protection material for the clay barrier is two feet of rocky soil cover (zone 2) material from the Shootaring Dam. Rock from the quarry area and Shootaring Dam will be used to protect the entire surface of the tailings cell and the drainage channels from the tailings. All soil and rock materials are on site and in sufficient volumes to complete the reclamation.

The reclamation schedule for the mill decommissioning and tailings reclamation is estimated to require 18 months. The sequence of tasks may result in interim periods of little or no reclamation activity, which may extend the time of completion.

The estimated costs for the mill decommissioning is $1,386,300. The reclamation costs for the tailings cell, which includes the ore disposal and the associated cover cap, is $2,944,700. These costs with a 15% contingency, 10% Uranium One Americas' management cost and the long-term maintenance costs are combined for a total project cost of $8,110,771.



URANIUM ONE AMERICAS

SHOOTARING CANYON MILL

TICABOO, UTAH

DATE: 10/23/02 D:\PROJECTS\2002-50\LOC

FIGURE 1-1. LOCATION OF THE SHOOTARING CANYON MILL SITE

2.0 SITE DESCRIPTION

The mill was designed and licensed to produce 1,004,000 pounds of U308 per year. The ore was processed in an acid circuit at an average daily rate of 500 tons per day and average ore grade of 0.15 percent U308. Tailings were contained by an engineered earthen and clay dam in a natural depression in the landscape. The existing tailings are located above the cross valley berm on a clay lining system above the natural sandstone in the tailings area. These tailings were placed in the facility during April through August of 1982 during 76 days of operation.

The facilities that exist at the mill site and tailings cell are illustrated on Figure 2-1. Major site features include the mill and associated support buildings, several ore stockpiles adjacent to the mill and the tailings cell. The figure shows the location of the Shootaring dam which was built to hold tailings, but no tailings were deposited between the dam and the cross valley berm. The cross valley berm, which was constructed from fine sand, holds all of the tailings. This figure also shows the east dike and north dike which contains 1 l.e(2) byproduct material.

The mill building contains the ore grinding and extraction processes including the grinding, extracting, and yellowcake packaging. Counter-current decantation (CCD) tanks and reagent tanks are on an exterior concrete pad. Associated facilities include the laboratory and shop buildings, generator building, exterior reagent storage tanks, fuel storage tanks, ore stockpiles, and outside materials storage areas, as shown in Figure 2-2. The tailings facility consists of a main tailings dam and several smaller berms upgradient of the main dam. During mill operations, ore was stockpiled at the ore pad just north of the mill after being weighed on the receiving scale. Ore was sampled prior to entering the mill building. The mill tailings were slurry pumped to the tailings cell area just west of the mill facility.

2.1 Land Ownership

The processing facility and its tailings disposal area are located on land purchased by Uranium One Americas from the State of Utah (State) on November 20, 1981. The patent for this property was obtained on March 1, 1982, from the State of Utah, which obtained the land from the U.S. Bureau of Land Management (BLM). Figure 2-3 shows which land is owned by Uranium One Americas, the State and BLM.

The United States reserved a right-of-way for ditches and canals constructed by authority of the United States in the purchased lands and has the oil and gas rights. The State of Utah reserved coal and other mineral rights. Uranium One Americas holds a lease from the State of Utah covering metalliferous minerals. A Garfield County road, constructed and maintained by Uranium One Americas through an agreement with the county, provides access to the processing facility from State Highway 276, as shown on Figure 2-3. Beehive Telephone Company (an independently owned telecommunications company) that serves the processing facility, Tony M mine and Ticaboo, Utah, was granted a right-of-way for a buried telephone cable that runs, in part, in a generally north to south direction through the eastern portion of the site.

Prior to termination of the source material license, Uranium One Americas will comply with the ownership requirements of Criterion 11 Appendix A to 10 CPR Part 40 for sites used for tailings

3.0 CURRENT SITE CONDITIONS AND OVERVIEW OF THE RECLAMATION PLAN

This section presents the updated information that was obtained to define the current site conditions and also presents an overview of the reclamation plan. A radiological survey and numerous test holes and pits were used to obtain samples of site material for defining the present site conditions.

3.1 Soils Characterization

An updated radiological survey of the site was conducted to define the radiological concentrations presently existing at the site. Radiological measurements were made in the field and samples were collected for radiological laboratory analysis. Samples were also collected during this time for the soil property measurements. Test pits, drill hole cuttings and hand auger sampling were used to define the materials that exist at the site. Some shallow surface samples were also taken for measuring radiological conditions near the ground surface.

3.1.1 Test Pits

Approximately 40 test pits were used to collect samples and define the lithologic conditions in the upper few feet of material at the Shootaring site. Figure 3-IA shows the sample site name and locations for the west area, which includes the tailings cell area and the Shootaring dam. Backhoe pits are shown in red on this location map. Some of the backhoe pits are also shown in cyan color if hand auger or drill hole measurements were also made at the same site. Figure 3-1B shows the sample site locations and names for the east area, which includes mainly the mill area. Some overlap with the west area exists in the east area map. Table A-1 in Appendix A presents the lithologic logs of the backhoe pit sites. Lithologic logs for additional backhoe pits in which a hand auger or drill hole was also used for lithologic definition are presented in Table A-4 of Appendix A

3.1.2 Test Holes

Twelve rotary air drill holes and approximately 40 hand auger drill sites were also used to define position and properties of the materials. The air rotary drill sites are shown in magenta on Figures 3-IA and 3- IB while the hand auger sites are shown in blue. Hand augers were also used at several of the pit locations to aid in definition of lithologic conditions at the pit locations. A drill hole and pit combination was used at one of the sites. Samples were collected from these test hole sites for radiological and materials measurements. Table A-2 of Appendix A presents the air rotary test hole lithologic information, while Table A-3 presents the lithologic logs for the hand auger test holes. Table A-4 presents the lithologic logs for the hand auger or drill hole and backhoe pit combination sample sites.

A thickness of the rock was measured on the tailings dam as shown in Table A-5 of Appendix A. These measurements show that the rock thickness averages 2.5 feet.

3.1.3 Gamma Survey

A gamma survey was conducted to define areas of soil contamination. The measurements were made using Ludlum micro-R meters calibrated using an NIST traceable Ra-226 source. Figure 3-2A presents the location and site name of the gamma measurements for the west area while Figure 3-2B presents the locations for the east area. Locations for gamma measurements in the mill area, which is part of the east area, are also shown on Figure 3-2C to a larger scale. Table B-1 in Appendix B presents the gamma survey location name, gamma reading, and any location remarks.

The gamma readings in units of µR/hr are presented in Figures 3-3A, 3-3B and 3-3C. Figure 3-3A shows a 20 µR/hr contour, which includes the entire existing tailings cell, the cross-valley berm, and the east and north dikes to the tailings cell. The letter A is shown on Figures 3-3B and 3-3C to define the location of the ore stockpiles. The letter 'B' shows the location of gamma readings above 20 µR/hr on the east side of the mill while letter 'C' labels a spill area on the northwest side of the mill. Area D is associated with the CCD circuit spills and some on the west side of the mill. Area E is two small areas of ore spillage on the southwest side of the maintenance shop and a small area just outside the fence to the east of the mill. Area F is upstream of the Shootaring dam and was not adequately cleaned up after the 1982 tailings solution spill. Area G is the cross valley berm while H is the east dike which contains 1l.e(2) material. Area I is the north dike ll.e(2) material and some area of elevated activity to the north of the dike due to ponding of tailings solution in this area prior to the placement of the north dike. A small area to the north of the north dike is included in gamma readings greater than 20 µR/hr to show the extent of this area. Figure 3-3A presents the location where radium-226 and thorium-230 exceed the cleanup level just above the Shootaring dam where fugitive solution ponded during 1982 (Area F). This area was found to have been inadequately cleaned up. This area includes the upstream toe of the tailings dam where elevated concentrations exist in the soil in the bottom portion of the rock protection for the dam. It also includes additional soil contamination from thorium-230 over the ponded area.

Figure 3-3B shows the east area, which includes the mill and the ore stockpile. A gamma reading of greater than 20 µR/hr exists around the entire ore stockpile and includes the scale area (Area A). The gamma readings in the mill area are shown at a larger scale in Figure 3-3C. This figure shows several areas that exceed 20 µR/hr in the mill area. Two small areas exist on the southwest side of the maintenance shop where some ore was washed or dropped from equipment parked in this area (Area E). The largest area exceeding 20 µR/hr is on the west side of the CCD circuits and the west portion of the mill (Area D). A large area is also present on the east side of the mill adjacent to the 600 area (Area B). Process solution spills have occurred in areas B and D but the affected area is likely smaller due to gamma shine in these areas. A small contaminated area exists just outside the fence east of the mill and appears to be ore material and was included in Area E.

A pre mill operation laboratory liquid effluent pond has been identified and sampled. Gamma readings were taken from four sample locations at varying depths up to seven feet with only one significant reading. A sample was collected from the elevated gamma reading location. The wet chemical sample analysis for U-nat, Ra226 and Th230 resulted in all levels below background. In order to verify the first analysis, a second analysis was performed using gamma spectrum with no results above background. No cleanup is planned for this site.

3.1.4 Laboratory Radiological Results

Table 3-1 presents the radiological properties for the soil samples collected at the Shootaring site. This table presents the sample location name, shown on Figures 3-IA or 3-1B, and also gives the coordinates for these sample locations. The top and bottom depths of the sample interval are also presented in the table. Radium-226 (Ra-226), thorium-230 (Th-230) and natural uranium (U-nat) concentrations were measured for these samples. Gamma values that were measured in the field for these samples are also tabulated along with these radiological results. Radium concentrations for these sites vary from very low levels for the majority of the mill site samples to a high of 76.6 pCi/g for a below grade sample of the ll.e(2) material in the north dike on the north side of the tailings cell. The highest Th-230 and U-nat concentrations were observed in the samples of the material immediately upstream of the Shootaring dam where cleanup of the solution affected soils was inadequate. This analysis of the level of contamination does not include ore samples (prefaced OP in Table 3-1) where concentrations are significantly greater.

Figure 3-4 presents a plot of the Ra-226 concentration versus gamma exposure rates. This figure shows that in general as the Ra-226 concentration increases, the gamma reading increases as expected. The figure also shows that a gamma exposure rate higher than 20 µR/hr indicates contamination above the proposed cleanup criteria. The site locations for the higher concentrations are listed on the figure also. The gamma reading for the NCI sample just north of the north dike is high compared to the Ra-226 concentration. Tailings solution existed at the location prior to the placement of the north dike which covers most of the area. Therefore it is likely that subsurface soil contamination is responsible for the elevated gamma levels.

There is only one small off-pile area that indicates elevated Th-230 concentrations relative to Ra-226. This area is where tailings water collected above the Shootaring Dam (Samples H-99-H102) as a result of a failure in the sump pump below the cross valley berm. The water was pumped back into the tailings impoundment and the surface soil/residues removed. However the radiological survey revealed areas where further remediation will be required. The areas exhibiting elevated gamma levels will be excavated to near background levels. The entire Area F has the potential for excess Th-230 contamination. Characterization of this area will be done to identify Th-230 contamination that exceeds the cleanup criteria.

TABLE 3-1. Radiological Properties from Soil Sample at Shootaring Canyon.

Sample Site	Coordinates East	Coordinates North	Date	Measurement top (ft.)	Measurement bottom (ft.)	Radium 226 Conc. (pCi/gm)	Radium 226 Precision (pCi/gm)	Thorium 230 Conc. (pCi/gm)	Thorium 230 Precision (pCi/gm)	Uranium (pCi/gm)	Gamma (uR/hr)
C4	62412	58040	06/05/2002	0.5	3.5	0.5	0.1	0.3	0	0.42	-----
CV4	62166	57809	06/04/2002	0	0.5	45.8	1.6	56.2	1	71.5	-----
D98	62836	57713	06/06/2002	3.5		0.6	0.1	0.4	0	0.57	60
DD1	63179	57052	06/06/2002	0	0.5	0.3	0.1	0.4	0	1.7	7
DD4	63194	57476	06/06/2002	0	0.5	0.2	0.1	0.1	0	3.24	12
DD4	63194	57476	06/06/2002	0.5	1	0.3	0.1	0.2	0	2.24	-----
DD5	63226	57505	06/06/2002	0	0.5	0.5	0.1	0.6	0.1	4.16	15
DD5	63226	57505	06/06/2002	0.5	1	0.8	0.1	0.8	0.1	4.12	-----
DD6	63207	57635	06/06/2002	0	0.5	0.4	0.1	0.5	0	1.8	10
DD6	63207	57635	06/06/2002	0.5	1	0.2	0.1	0.2	0	0.52	-----
DD7	63420	57438	06/06/2002	0	0.5	0.6	0.1	0.4	0	3.35	16
DD7	63420	57438	06/06/2002	0.5	1	0.3	0.1	0.2	0	2.59	15
DD8	63457	57771	06/06/2002	0	0.5	74.1	2.7	83.3	1.8	153	60
DD8	63457	57771	06/06/2002	0.5	1	10.7	0.4	17.5	0.5	38.9	45
DD9	63532	57953	06/06/2002	0	0.5	3.2	0.2	3.6	0.2	4.81	19
DD9	63532	57953	06/06/2002	0.5	1	0.4	0.1	0.3	0	2.19	16
ED2	62123	58113	06/05/2002	5	10	2.1	0.2	5.7	0.3	29.2	-----
H100	61259	56753	06/07/2002	0	0.25	31.7	1.1	49.5	0.8	12	42
H101	61604	56774	06/07/2002	0	0.5	12.3	0.4	35.2	0.7	22.5	31
H101	61604	56774	06/07/2002	0.5	1	2.1	0.2	162	1.7	97.4	22
H102	61250	56753	06/07/2002	1	1.5	10	0.4	95.4	1.4	18.6	24
H99	61242	56822	06/07/2002	0	0.5	0.3	0.1	1.9	0.2	11.2	12
H99	61242	56822	06/07/2002	0.5	1	4.5	0.2	62.4	1	24.2	17
NC1	62173	58588	06/07/2002	0	0.5	27.9	1	27.2	0.7	5.15	90
NC1	62173	58588	06/07/2002	0.5	1	3.5	0.2	79.8	1.3	48.3	90
ND2	62126	58531	06/05/2002	5	10	57.9	2.1	81.1	1.3	52.4	-----
ND3	61975	58663	06/05/2002	5	10	76.6	2.7	85.4	1.2	43.6	-----
NP4	62237	58532	06/04/2002	2	2.5	0.5	0.1	0.2	0	0.31	-----
OP1	63881	58486	04/04/2002	-----	-----	230	2.3	370	2.7	0.23	-----
OP2	63845	58528	04/04/2002	-----	-----	270	2.5	490	3.1	640	-----
OP3	63838	58432	04/04/2002	-----	-----	260	2.5	350	2.5	632	-----
OP4	63790	58483	04/04/2002	-----	-----	190	2	320	2.5	523	-----
OP5	63788	58383	04/04/2002	-----	-----	210	2.2	520	4.2	502	-----
OP6	63735	58433	04/04/2002	-----	-----	250	2.4	390	3.3	476	-----
OP7	63740	58332	04/04/2002	-----	-----	250	2.3	430	3.3	540	-----
OP8	63691	58386	04/04/2002	-----	-----	200	2.1	320	2.6	468	-----
OP9	63692	58286	04/04/2002	-----	-----	310	2.6	360	2.2	649	-----
OP10	63640	58338	04/04/2002	-----	-----	240	8.4	460	2.9	691	-----
OP11	63643	58241	04/04/2002	-----	-----	260	8.7	540	3.6	619	-----
OP12	63586	58291	04/04/2002	-----	-----	280	8.8	330	2.5	691	-----
OP13	63610	58168	04/04/2002	-----	-----	220	8.1	290	2.4	498	-----
OP14	63576	58211	04/04/2002	-----	-----	240	8.4	330	2.4	751	-----
OP15	63540	58252	04/04/2002	-----	-----	240	8.4	320	2.6	528	-----
OP16	63514	58215	04/04/2002	-----	-----	270	9	270	1.9	489	-----
OP17	63514	58069	04/04/2002	-----	-----	260	8.7	320	2.4	640	-----
OP18	63482	58135	04/04/2002	-----	-----	290	9.2	220	1.7	555	-----
OP19	63412	58104	04/04/2002	-----	-----	340	10	300	2.3	697	-----
OP20	63459	58053	04/04/2002	-----	-----	210	2.3	360	2.6	584	-----
OP21	63385	58066	04/04/2002	-----	-----	300	2.7	380	2.9	591	-----
OP22	63352	58043	04/04/2002	-----	-----	340	2.9	350	2.6	751	-----
OP23	63371	58000	04/04/2002	-----	-----	240	2.5	350	2.8	436	-----
OP24	63316	58022	04/04/2002	-----	-----	97	1.5	150	1.8	232	-----
OP25	63308	57948	04/04/2002	-----	-----	110	1.7	130	1.6	267	-----
OP26	63382	57947	04/04/2002	-----	-----	250	2.4	290	1.9	554	-----
OP27	63393	57883	04/04/2002	-----	-----	120	4.3	140	1.4	250	-----
OP28	63416	57856	04/04/2002	-----	-----	106	3.8	96	1.3	162	-----
OP29	63446	57844	04/04/2002	-----	-----	99.2	3.6	93	1.3	169	-----
OP30	63468	57912	04/04/2002	-----	-----	88.2	3.9	94	1.5	149	-----
OP32	63542	58063	06/06/2002	3.7	4.2	6	0.3	6.9	0.3	33.9	280
OP32	63542	58063	06/06/2002	4.2	4.6	0.2	0.1	<0.1		7.85	170
OP33	63624	58107	06/06/2002	2.9	3.4	4.8	0.2	5.3	0.3	22.6	250
OP33	63624	58107	06/06/2002	3.4	3.9	1	0.1	0.9	0.1	7.38	160
T3	61918	58074	06/05/2002	8.0	10.7	45.6	1.6	12.4	0.5	100	-----
T4	61953	58456	06/05/2002	10.0	13.0	51.8	1.9	28.8	0.8	21.5	-----
T7	61785	58315	06/05/2002	3.7	3.9	139	5.0	3800	25	3880	-----
SY1	63055	57190	08/19/2002	0	0.5	6.1	0.3	10.2	0.4	6.73	21
SY1	63055	57190	08/19/2002	0.5	1.0	1.6	0.1	2.5	0.2	7.11	16

3.2 Tailings Moisture and Limited Drainage from Under Drain System

Three wells were completed into the tailings during the drilling of the test holes. Figure 3-5 shows the location of the three tailings wells, T4, T5 and T6. This figure also shows the location of the underdrain piping for the tailings drain system. This piping lies on top of the clay barrier and has a filter layer of sand and rock on top of the perforated pipes. The Entrada red sand is also used as a drain blanket on top of the clay. The elevations of the top of the existing clay barrier are presented in Figure 3-6. Tailings well T4 was placed near the lowest portion of the clay liner. The clay was generally placed to a minimum thickness of two feet. Recent testing defined one location with a thickness of 16 inches (ED2) and a few locations with a thickness of 18 inches. These contours were developed for the surface prior to the construction of the cross valley berm or the placement of any tailings material in the existing cell. The drain system is tied to the sump on the down-gradient side of the cross valley berm. Table 3-2 presents the completion details for the three tailings wells and also the observed water levels since completion of these wells. None of the three wells have shown any saturation in the tailings other than some water observed in the bottom of well T5 after the August 20th rain event. Additional rain after the August 20th precipitation has not created any saturation in well T5. This water existed only in the cap portion of the bottom of the well and therefore was water that was retained after some infiltration occurred. The dry conditions could have prevented the bentonite seal from adequately limiting water from moving down the well annulus in this area. A very limited amount of saturation in some locations may exist in the material just above the clay layer with infiltration through the tailings likely occurring as partially saturated flow after heavy rainfall events.

TABLE 3-2. BASIC WELL DATA AND WATER LEVELS FOR THE SHOOTARING TAILINGS WELLS.

WELL NAME	NORTH COORD.	EAST COORD.	CASING DIAMETER (in)	TOTAL DEPTH (ft-mp)	STICKUP (ft)	WATER LEVEL DATE	WATER LEVEL DEPTH (ft-mp)	SLOTTED CASING (ft-lsd)	SAND PACK (ft-lsd)
T4	58,456	61,953	2	20.0	1.2	06/07/2002	>20.0	12.9-17.9	10.0-17.9
						07/18/2002	>20.0		
						07129/2002	>20.0		
						08/05/2002	>20.0		
						08124/2002	>20.0		
						10/03/2002	>20.0		
						10127/2002	>20.0		
						02/13/2002	>20.0		
						02/19/2003	>20.0		
T5	58,371	61,891	2	10.0	2.5	06/07/2002	>10.0	2.5- 7.5	0.7-7.5
						07/18/2002	>10.0		
						07129/2002	>10.0		
						08/05/2002	>10.0		
						08124/2002	9.8		
						08126/2002	9.8		
						09/03/2002	>9.9		
						10/03/2002	>9.9		
						10/27/2002	>9.9		
						02/13/2002	>9.9		
						02/19/2003	>9.9		
T6	58,133	61,801	2	11.7	2.9	06/07/2002	>11.7	3.8 - 8.8	1.0-8.8
						07/18/2002	>11.7		
						07/29/2002	>11.7		
						08/05/2002	>11.7		
						08/24/2002	>11.7		
						10/03/2002	>11.7		
						10/27/2002	>11.7		
						02/13/2002	>11.7		
						02/18/2003	>11.7		

Flow to the sump has been monitored in 2002 and early 2003 to define the rate of drainage from the under drain system. Table 3-3 presents the measurements of the very small flow rates from the under drain system to the tailings sump. The quantity in Table 3-3 is the volume of water reporting to the sump between the dates and is used to calculate the average flow rate over the elapsed time. Some of the flow can be overland flow from the downstream side of the cross valley berm. This table shows that the flow rate has varied from a high of 0.15 gal/min for measurement between February 14 to February 20, 2003 to a fairly steady low rate of 0.008 gal/min between May 16th and July 14th, 2002. This very small rate was during May, June and July prior to rains while the largest rate is after a typical rainy season. Figure 3-7 shows the drainage area that presently contributes to the under drain system. This drainage area will be reduced to the reclaimed tailing cell plus the area out to the present drainage divide on the northwest side of the tailings after reclamation. Therefore, the area contributing runoff to the post-reclamation tailings area will be a small fraction of the present contributing area. With the configuration of the reclaimed tailings to create positive drainage, the closed basin capture of runoff in the tailings area will be eliminated. This will dramatically reduce the contribution of runoff to the drainage from tailings. These rates indicate that recharge through the tailings is very small.

TABLE 3-3. TAILINGS UNDER DRAIN SUMP INFLOWS AT SHOOTARING CANYON.

Date	Activity	Total time (hr)	Quantity pumped (gal)	Flow rate (gpm)	Sump sample collected
04/03/2002	instantaneous flow estimate			0.037	4/3 sample liquid sample
4/16/02 to 5/16/02	pump sump	744	1505	0.034	4129 sump liquid sample
5/16/02 to 6/26/02	pump sump	984	473	0.008	
6/26/02 to *7/14/02*	pump sump	432	215	0.008	
7/14/02 to 7/31/02	rain event (7/28) clean sump on 7/31				7/29 sump sample includes rain & sediment
7/31/02 to 8/5/02	pump sump	144	86	0.009	8/5 sump liquid sample
8/5/02 to 8/23/02	rain event (8/20) clean sump on 8/23				
8/23/02 to 9/2/02	pump sump	237	280	0.020	9/2 sump liquid sample
9/2/02 to 9/7/02	pump sump	120	172	0.024	
9/7/02 to 9/12/02	rain event (9/11) clean sump on 9/12				
9/7/02to 9/12/02	rain event clean sump on 9/12				rain on 9/7, 9/11, 9/28 and 9/29
9/12/02 to 10/5/02	pump sump	552	1849	0.056	
10/05/02 to 10/27/02	rain event and pump sump	528	2365	0.074	includes rain runoff from 10/27 event
10/27/02 to 11/20/02	pump sump	576	430	0.012	
11/20/02 to 12/14/02	pump sump	576	731	0.021	
12/14/02 to 01/11/03	pump sump	672	989	0.025	rain 01/10/03, 0.3 inches
01/11/03 to 01/21/03	pump sump	240	860	0.060	
01/21/03 to 02/01/03	pump sump	264	645	0.041	
02/01/03 to 02/14/03	pump sump	312	860	0.046	rain on 2/13 of 0.7 inches
02/14/03 to 02/20/03	pump sump	144	1333	0.154	0.5 inches of rain on 2·18

Note: All sump liquid and sediment is pumped into lined pond on tailings facility.

Water quality samples have also been taken from the tailings sump to define the concentrations of water draining from the under drain system. The results are given in Table 3-4 which show that the total dissolved solid concentration is very high for this water with a TDS typically greater than 30000 mg/1. A very high sulfate concentration also exists in the water. Uranium concentration is typically greater than 10 mg/1, indicating that a significant percentage of the water is partially saturated flow coming from the tailings material. The molybdenum and selenium concentrations are also slightly elevated above background concentrations. The very limited rate of drainage from the under drain system therefore contains high TDS, sulfate and uranium concentrations but the concentrations of the remainder of the hazardous constituents are low.

TABLE 3-4. WATER QUALITY FROM THE TAILINGS SUMP ATTACHED TO THE UNDER DRAIN SYSTEM

Well Name	Date	pH (units)	TDS (mg/l)	Cl (mg/l)	S04 (mg/l)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	F (mg/l)	N03+N02 - (mg/1)
TAILS SUMP	04/03/2002	7.13	32400	980	19800	9.31	0.117	0.033	6.4	48. 7
	04/29/2002	8.12	50400	1570	30700	12.20	0.147	0.053	8.3	12.0
	07/29/2002	7.94	28500	785	15900	4.95	0.056	0.256	2.0	67.3
	06/05/2002	7.80	38500	1090	23500	11.20	0.199	0.056	7.8	17.9
	09/02/2002	7.96	44700	1410	28300	13.40	0.151	0.055	9.2	9.9

Well Name	Date	As (mg/l)	Ba (mg/l)	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Pb (mg/l)	Hg (mg/l)	Ag (mg/l)	Zn (mg/l)
TAILS SUMP	04/03/2002	0.005	0.12	<0.001	0.004	0.056	< 0.001	< 0.001	< 0.001	0.12
	04/29/2002	0.006	<0.10	<0.001	< 0.010	0.070	< 0.002	< 0.001	< 0.005	0.13
	07/29/2002	0.017	0.20	< 0.001	<0.010	0.050	0.009	< 0.001	<0.005	0.37
	08/05/2002	0.011	<0.10	<0.001	< 0.010	0.040	0.005	< 0.001	<0.005	0.23
	09/0212/02	0.011	<0.10	<0,001	<0.010	0.070	<0.002	< 0.001	<0.005	0.14

3.3 Building Surface Contamination

A recent surface contamination survey was done in the mill buildings in order to assess the airborne radiation exposure to workers and to assess the feasibility of decontaminating the structures. The survey was biased in that areas most likely to be contaminated were sampled. The results are given in Table 3-5 and show that surface contamination levels are relatively low. The data for areas near the kerosene tanks indicate high removable levels. However, these data probably don't reflect the levels after the kerosene residue is removed and thus should not be considered. Without the kerosene residue samples, the total gross alpha contamination averaged 372 dpm/100 cm^2 with a standard deviation of 125 dpm/100 cm^2. The removable portion averaged 30 dpm/100 cm^2 with a standard deviation of 47 dpm/100 cm^2. This would indicate a minimum removable fraction of 8 percent, depending on the efficiency factor assumed for the wipe tests. Working in these low levels of contamination should not pose a high risk to employees or excessive releases to the environment.

The yellowcake section has been sealed and no measurements were made. However it is known that high levels of surface contamination exist. The decommissioning of the yellowcake processing area (YCPA) will require additional procedures to minimize radiation exposure to personnel and limit the release to the environment. A primary consideration in planning the YCPA work is weather conditions, especially wind speeds. A special radiation work permit (RWP) will be developed, including special engineering controls, for performing this work.

Anticipated engineering controls include spraying the equipment with a tack coating after a wash down to fix the contamination while removal and transport to the tailings cell. The SERP will approve all RWPs. See Appendix I for a list of Titles of Standard Operating Procedures (SOP) that are in place and will be utilized and/or updated or modified as needed during the site reclamation and decommissioning. Radiation worker training will be given to all personnel working on the reclamation and decommissioning activities. Personnel working on the site reclamation and decommissioning will be supervised for radiation safety and general safety, and to insure that the work follows the approved Tailings Reclamation Plan.

Table 3-5 Radiation Surveys in Mill Buildiings-Floor/Sump Areas

Date	Area	Location	Gamma (Ur/hr)	Total Alpha (dpm)	Removable Collection date	Removable count date	Removable Alpha (dpm)
08/09/2002							
	300 Leach	1) 10ft north of SAG	11	498	08/13/2002	08/16/2002	211
		2) under SAG	12	298	08/13/2002	08/21/2002	30
		3) south end under SAG	19	199	08/13/2002	08/21/2002	30
		4) SAG sump west side	16	199	08/13/2002	08/21/2002	15
		5) steps east side into 500area	10	298	08/1312002	08/21/2002	14
		6) SW corner	19	398	08/1312002	08/21/2002	18
08/09/2002							
	500SX	1) 1Oft inside main door	18	398	08/13/2002	08/21/2002	13
		2) preg strip soln tank	16	418	08/13/2002	08/23/2002	25
		3) sump kerosene tank	15	298	08/13/2002	08/21/2002	27
		4) floor kerosene tank	13	418	08/13/2002	08/21/2002	264
		5) kerosene tank west	12	796	08/13/2002	08/23/2002	542
		6) south man door floor	10	398	08/13/2002	08/23/2002	15
		7) SW man door floor	12	298	08/13/2002	08/23/2002	12
		8) NW man door floor	18	498	08/13/2002	08/23/2002	36
08/09/2002							
	700 Reagent	1) South end floor near sump	B	318	08/13/2002	08/23/2002	13
		2) under reagent tanks	9	199	08/13/2002	08/23/2002	11
		3) center of floor	8	318	08/13/2002	08/23/2002	14
08/09/2002							
	Sand filters	1) center floor	140	597	08/13/2002	08/21/2002	16
		2) south floor near sump	90	597	08/13/2002	08/21/2002	16
		3) north floor	65	398	08/13/2002	08/21/2002	14
		Mean	26	392		Mean	67
		standard Dev.	34	150		Standard Dev.	131

Survey meters: Ludlum Model 19, SN 34944 Calib 4-11-02
Ludlum Model 177, SN 14877/4028, Callb 3-28-02, eff 13.4%
SAC-4 SN 361, Calib 5-28-02, eff 41.3%
Survey In Mill conducted by D. Winters and reading swipes by F. Craf

3.4 Tailings Reclamation Performance Objectives

The project goal is to remove all items and soils contaminated with byproduct material and place them into the tailings impoundment. Once the mill area has been cleaned and any contaminated soils or materials have been identified and removed, the site will be released for unrestricted use. See Sections 8, 10 and 11 on mill site decommissioning for a complete explanation, scheduling and cost analysis.

The tailings will be isolated from groundwater by placing a clay cap over the cell. This will minimize infiltration and reduce the radon emissions to less than 20 $pCi/m^2/s$. The cap will be tied into the existing clay liner to encapsulate the tailings. One hundred forty feet of sandstone lies between the liner system and the groundwater. A cover system has been designed to control erosion, disturbance, and dispersion of tailings by natural forces for a minimum of 1,000 years.

During the time of mill site cleanup, the tailings pile will be kept dewatered and stabilized in preparation for receiving the mill site wastes and the specifically-designed radon attenuation cap. This engineered cap will be a combination of clay, soils and rock placed in layers. Quality control practices are specified to assure compliance with the design specifications.

The desired end result of the design, construction, operation, and closure of the tailings disposal system has been planned with the objective of creating a facility that, after closure, will endure for up to one thousand (1000) years without requiring either monitoring or maintenance while continuing to provide an environmentally safe and satisfactory performance. Factors of long-term concern with respect to uranium tailings final disposal are the dispersal of tailings by erosion, the contamination of groundwater, and the release of radon to the atmosphere. These and other concerns addressed in 10 CPR Part 40, Appendix A and other NRC regulations are addressed in following sections.

3.4.1 Nonproliferation Of Small Waste Disposal Sites

To avoid proliferation of small waste disposal sites and thereby reduce perpetual surveillance obligations, radioactive byproduct, contaminated equipment, and contaminated scrap from milling operations will be placed, with NRC approval, in the tailings cell for disposal. Precautions will be taken to place the materials in the tailings in such a way as to minimize any future subsidence of the area.

3.4.2 Site And Design Criteria

Uranium One Americas' tailings disposal facility was designed to minimize the dispersal of tailings by wind and water, to minimize the upstream rainfall catchment area, to minimize the embankment and cover slopes, to minimize erosion of the cover, to locate the impoundment away from capable faults, and to promote deposition on top of the cover. Specific design criteria for the tailings impoundment and dam are detailed in Woodward-Clyde Consultants studies and designs. Refer to the list of references in Section 14. The design of the cover and reclamation is presented in this document. The design features of the impoundment and cover will provide reasonable assurance of the longevity of the tailings disposal facility (See Section 6).

3.4.3 Control Of Radon Release And Gamma Exposure Rates

This plan covers the design of the radon barrier for the tailings impoundment consisting of one and one-half (1.5) feet of compacted clay covered by two (2) feet of rocky soil covered by a minimum of eight (8) inches of a rock cover. Prior to placement of the clay, one (1) foot of interim/grading cover will be placed on the tailings area. The radon barrier was designed to yield a radon emanation rate of 20 pCi/m^2/sec or less. One gamma-ray exposure rate measurement at approximately one meter above the cover system will be made per acre of radon barrier, using a Ludlum Model 19 micro-R meter (or equivalent), to demonstrate that the cover reduces the gamma exposure rate to background levels.

3.4.4 Operational Environmental Monitoring Program

The operational and interim environmental monitoring programs are described in Section 5.5.6. of the Source Material License Renewal Application SUA 1371. Docket No. 40-8698, March 11, 1996. See Appendix I for Titles of Standard Operating Procedures that are to be utilized for environmental monitoring. This program will be continued during the decommissioning of the site.

3.4.5 Control Of Airborne Effluents

All airborne effluents from milling operations will be reduced to levels that are As Low As Reasonable Achievable (ALARA), which in turn controls exposures to populations around the site and site contamination to the maximum extent reasonably achievable.

Airborne effluent controls include but are not limited to water spraying to minimize dust and interim cover over radioactive materials.

3.4.6 Hazardous Constituents

Uranium One Americas does not reasonably expect any compound on the list of specific constituents presented in 10 CPR Part 40, Appendix A (Criterion 13) to be present in the groundwater under the Uranium One Americas mill or tailings area as a result of site operations. Water monitoring since tailings deposition in 1982 has not shown any tailings or mill constituent migration.

3.4.7 Financial Surety

At the present time surety arrangements have been established at the Wells Fargo Bank National Association with an account in the name of Uranium One Americas, Inc., a Surety Trust Agreement which names the Utah Department of Environmental Quality, Division of Radiation Control as the beneficiary. The surety amount as of December 12, 2011 was $8,110,771. These funds are sufficient to carry out the decontamination and decommissioning of the facility and site, and for reclamation of the tailings disposal area (60 acres) as of this date. The amount of funds insured by the surety arrangement is based on cost estimates and the decommissioning plan approved by the Commission in November 1983 and 1988 which provide for (1) decontamination and decommissioning of mill buildings and the facility ·site to levels which would allow unrestricted use of these areas and (2) the reclamation of the large 60 acre tailings disposal area in accordance with the approved technical criteria.

3.4.8 Rodent and Plant Penetration into the Radon Barrier

At the completion of the reclamation phase there will be a minimum depth of one-half (1.5) feet of clay cover, followed by two (2) feet of soil cover and finally eight (8) inches of rock cover placed on top of the tailings in the impoundment area. The rock cover material will make the surface of the impoundment an unlikely habitat area for burrowing rodents, based on the size and thickness of the rock cover.

The establishment of plant growth is improbable for several reasons. Influencing factors include the low average annual precipitation of 7 inches (18 cm); frequent droughts; extreme temperatures; and the fact that the surface of the impoundment will be covered with cobble which has poor moisture-holding capacity and little to no organic content. Therefore, there is little concern for roots penetrating the clay barrier and establishing a pathway for radon migration to the surface.

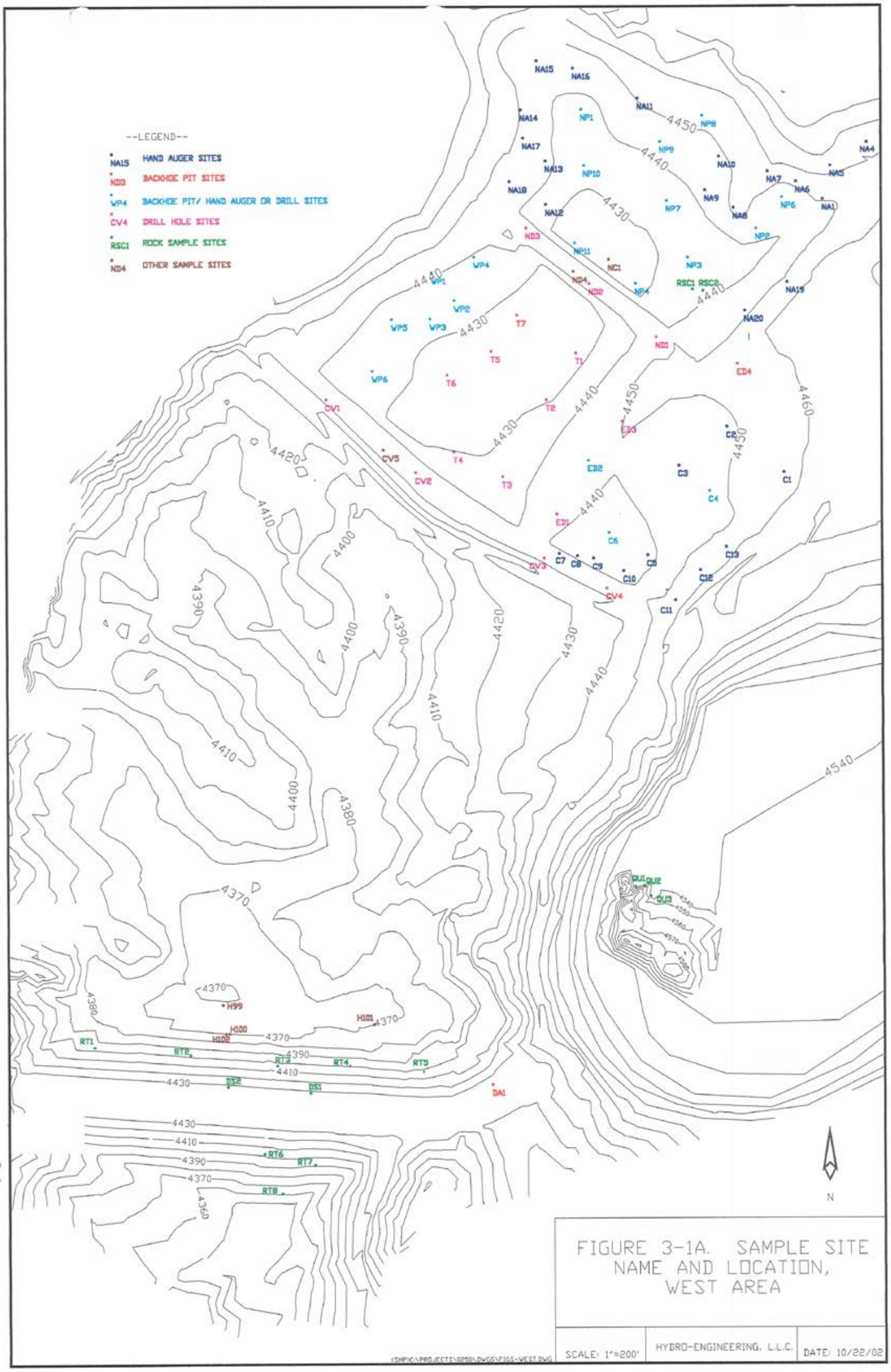


FIGURE 3-1A. SAMPLE SITE NAME AND LOCATION, WEST AREA

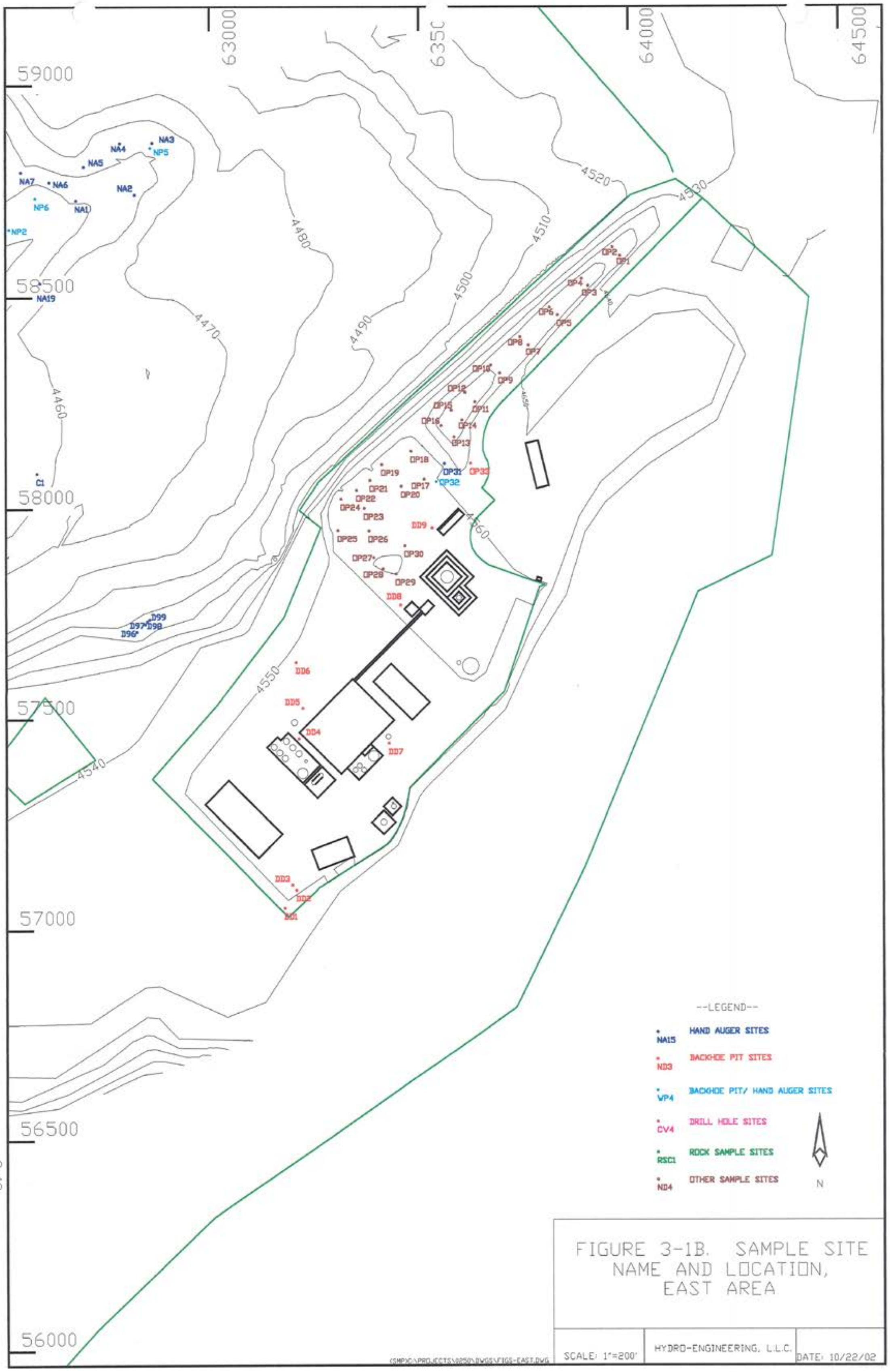
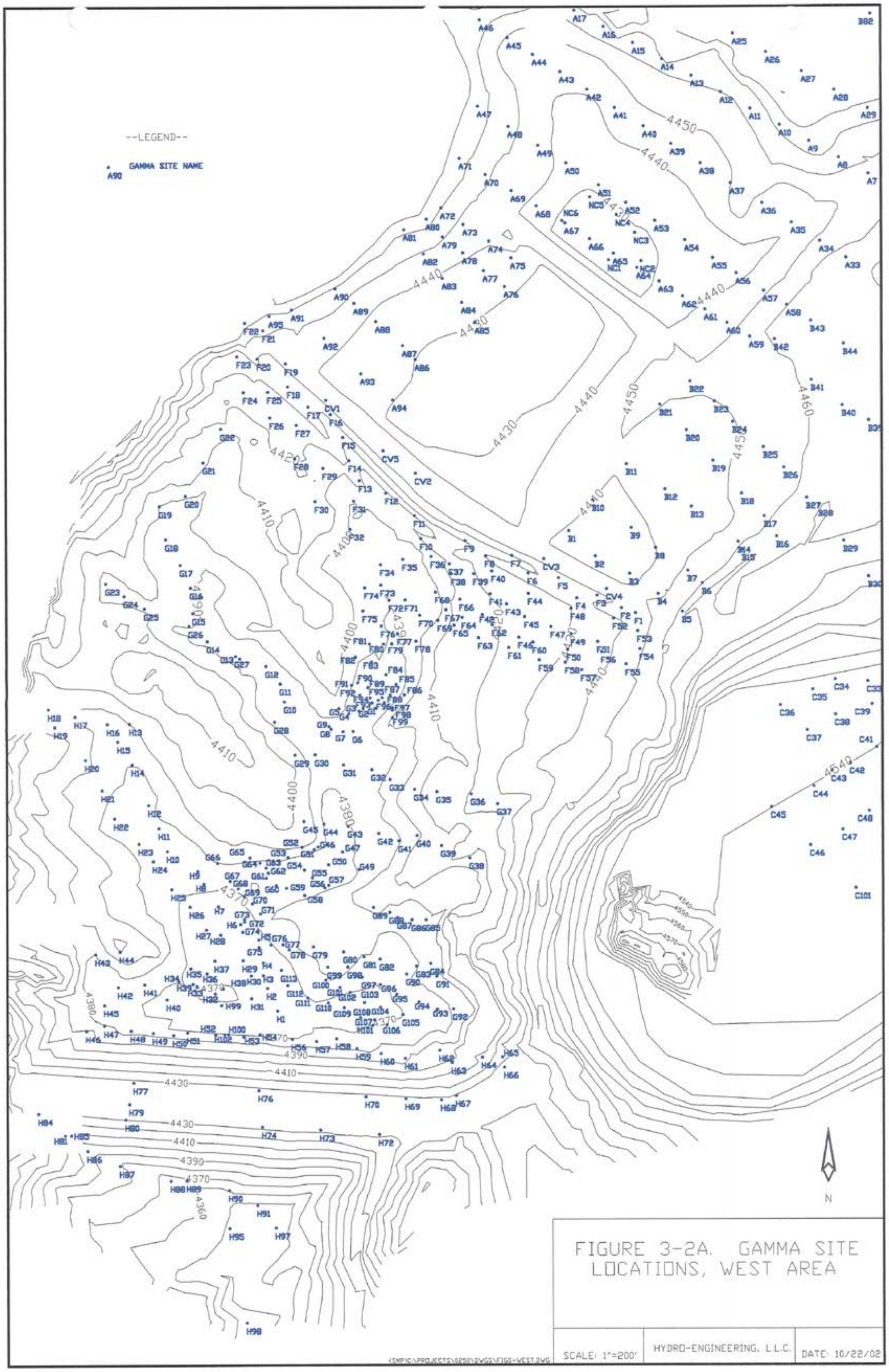


FIGURE 3-1B. SAMPLE SITE NAME AND LOCATION, EAST AREA

3-12


--LEGEND--
GAMMA SITE NAME
A90
FIGURE 3-2A. GAMMA SITE LOCATIONS, WEST AREA
SCALE: 1"=200'
HYDRO-ENGINEERING, L.L.C.
DATE: 10/22/02
N

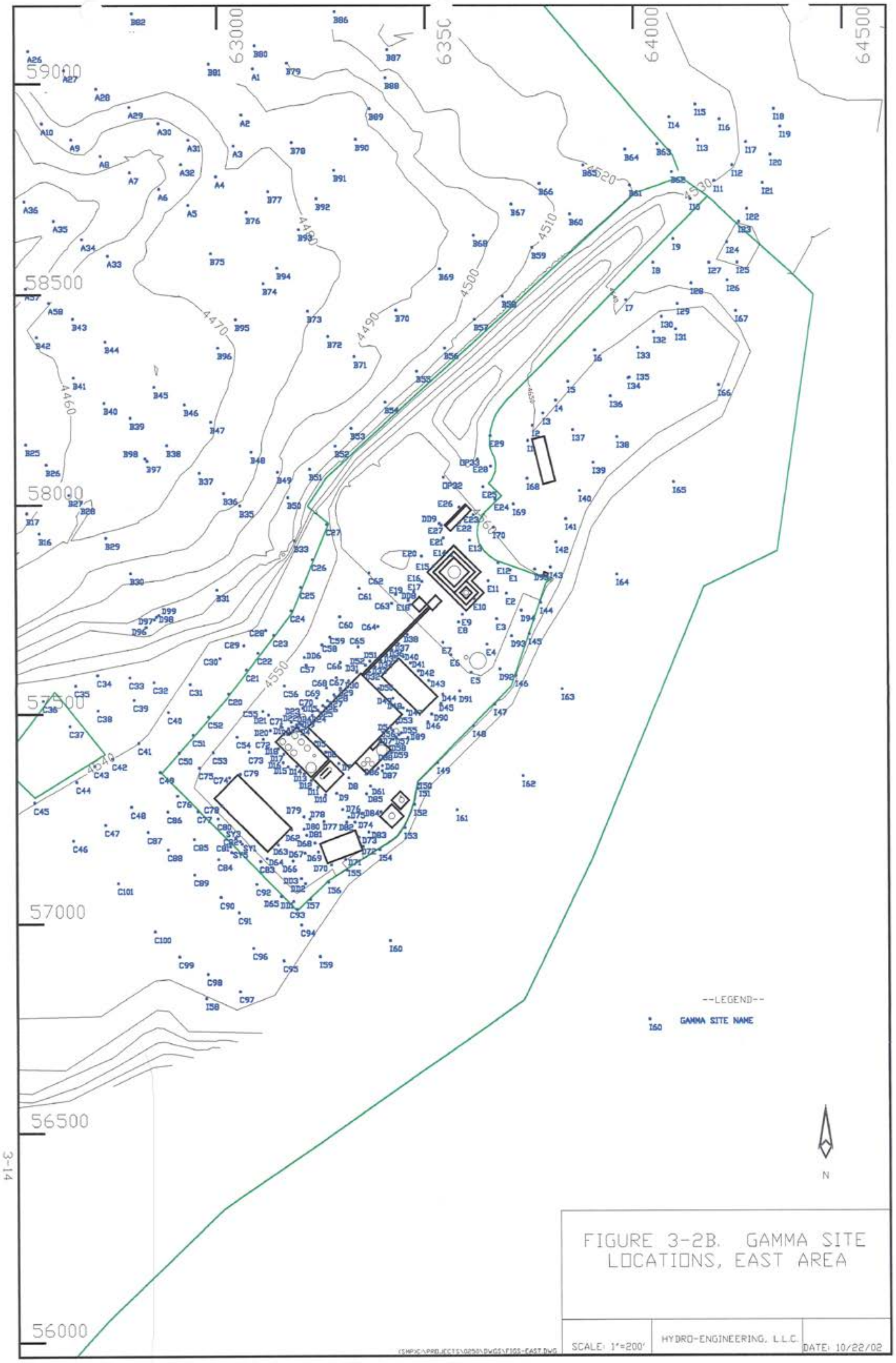


FIGURE 3-2B. GAMMA SITE LOCATIONS, EAST AREA

3-14

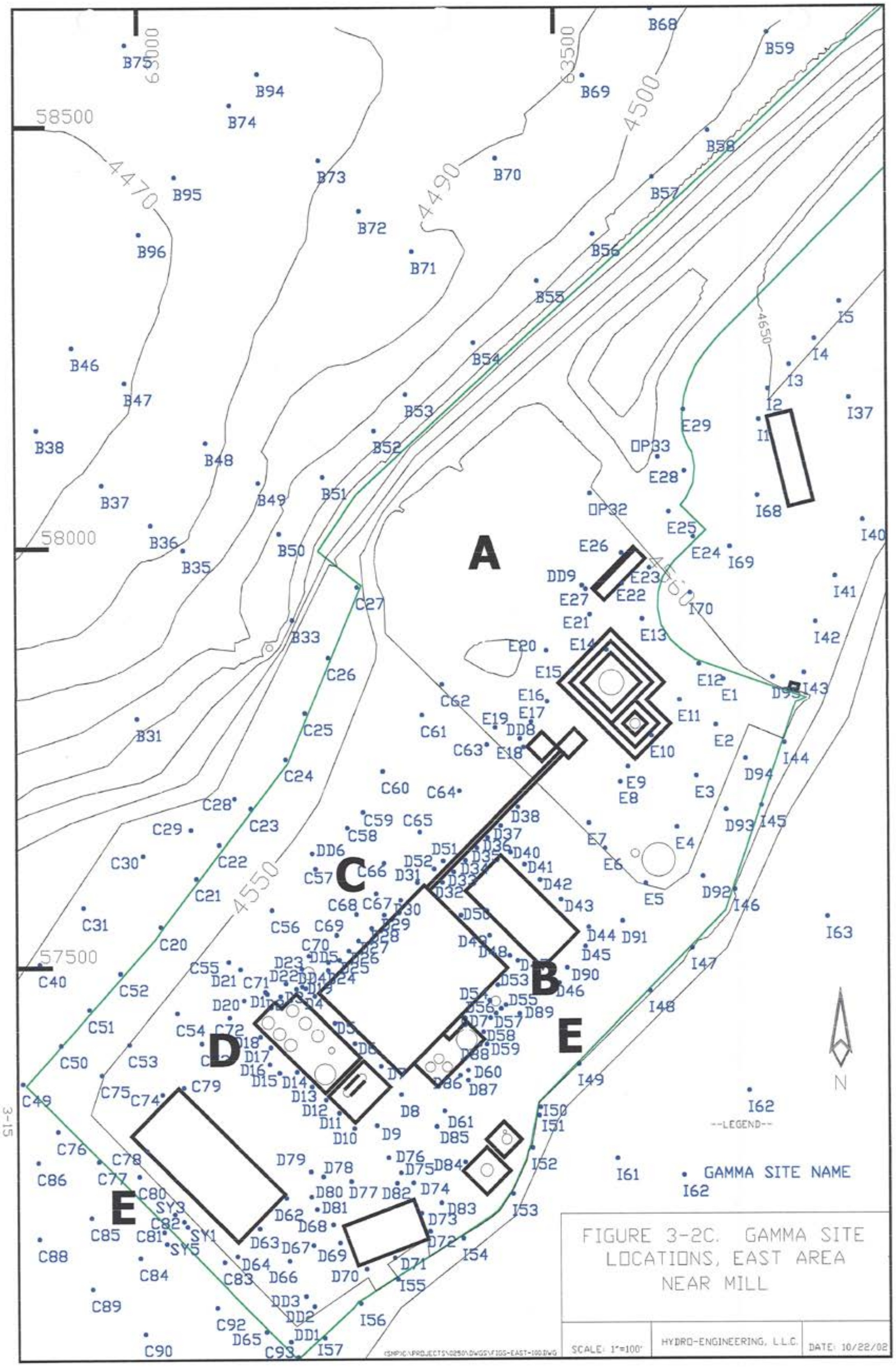


FIGURE 3-2C. GAMMA SITE LOCATIONS, EAST AREA NEAR MILL

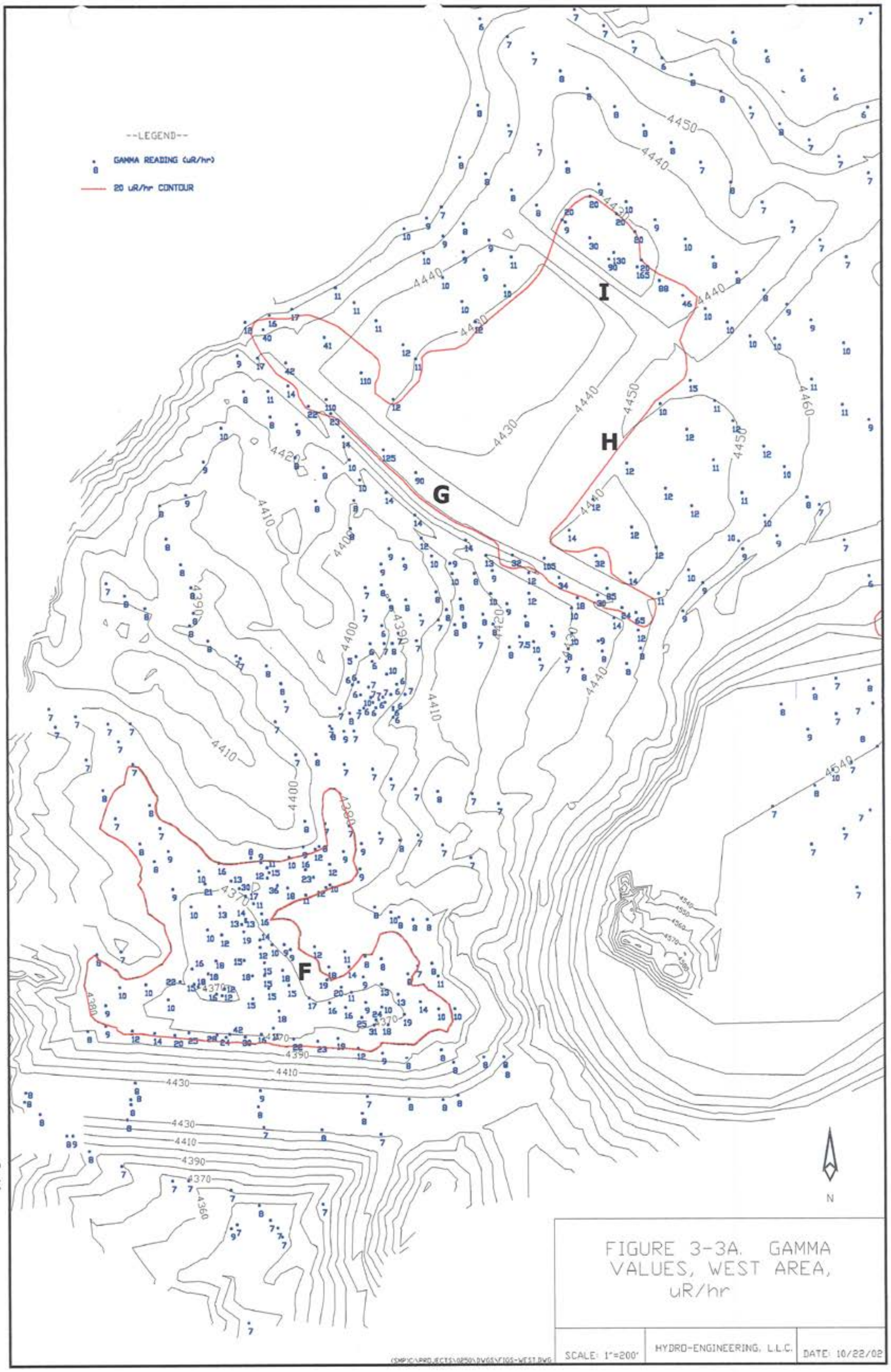
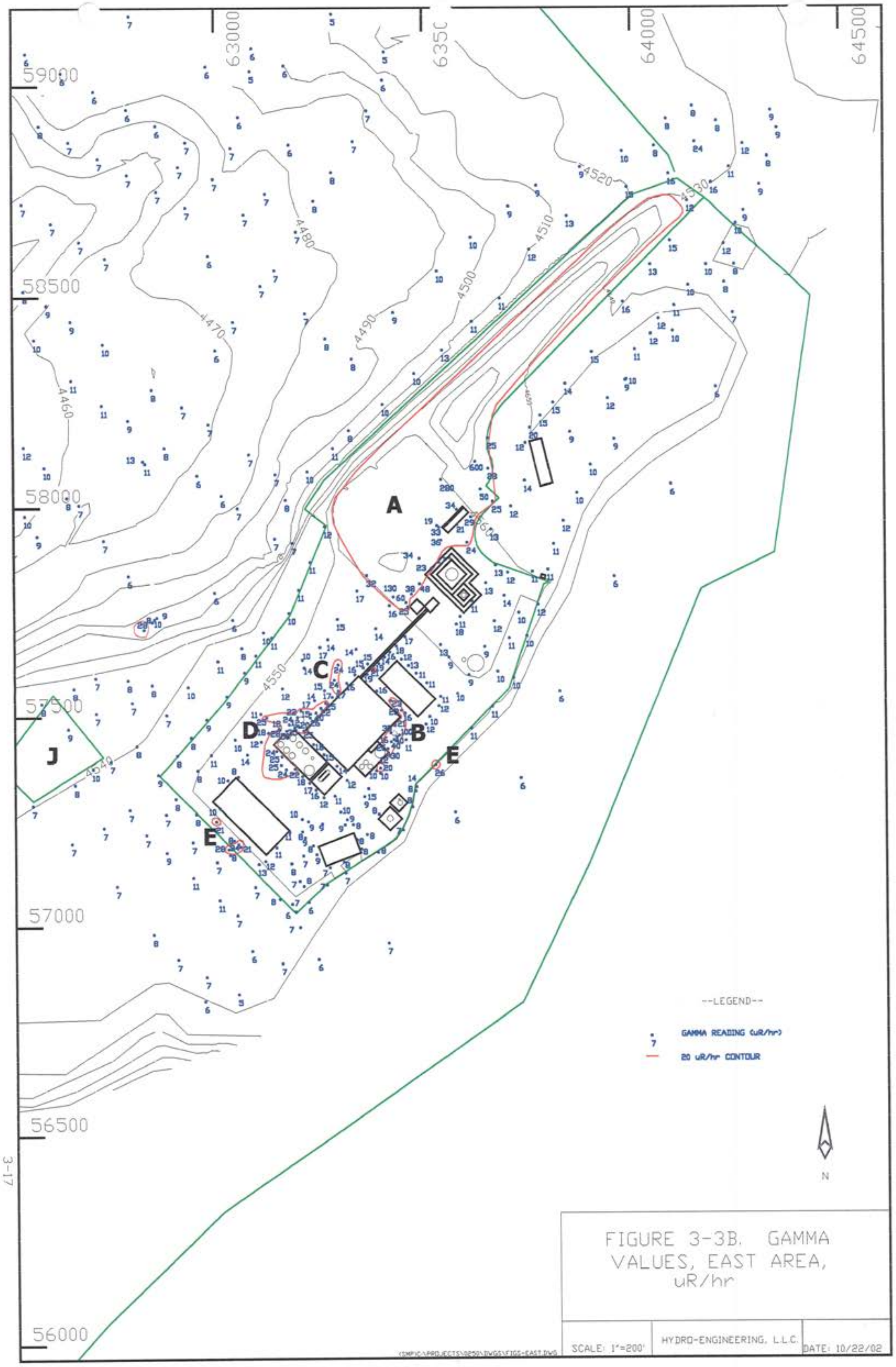
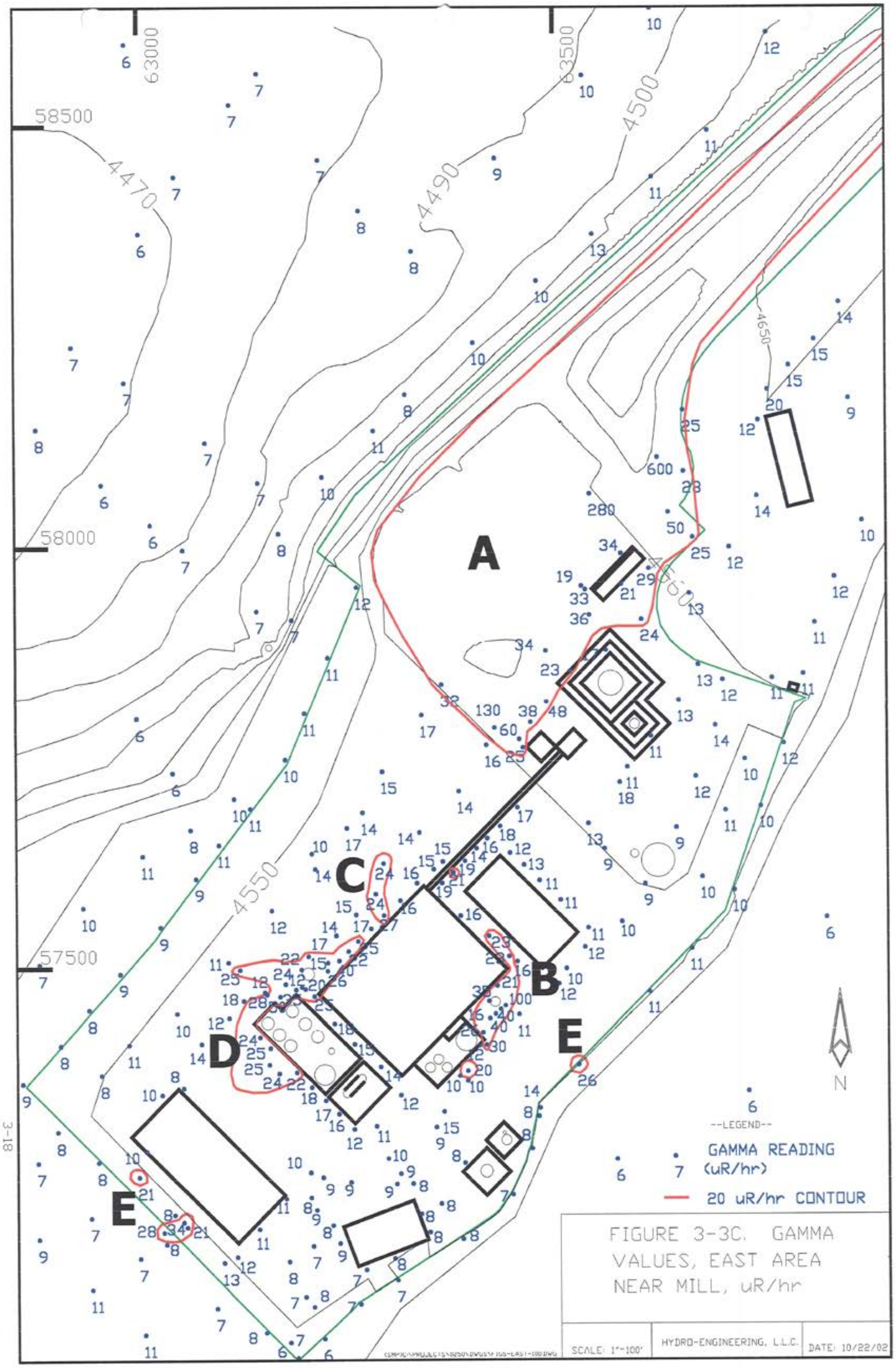


FIGURE 3-3A. GAMMA VALUES, WEST AREA, uR/hr

3-16



63000
63500
64000
64500
59000
58500
58000
57500
57000
56500
56000
A
B
C
D
E
J
--LEGEND--
GAMMA READING (uR/hr)
20 uR/hr CONTOUR
N
FIGURE 3-3B. GAMMA VALUES, EAST AREA, uR/hr
SCALE: 1"=200'
HYDRO-ENGINEERING, L.L.C.
DATE: 10/22/02


--LEGEND--
GAMMA READING (uR/hr)
20 uR/hr CONTOUR
FIGURE 3-3C. GAMMA VALUES, EAST AREA NEAR MILL, uR/hr
SCALE: 1"=100'
HYDRO-ENGINEERING, L.L.C.
DATE: 10/22/02

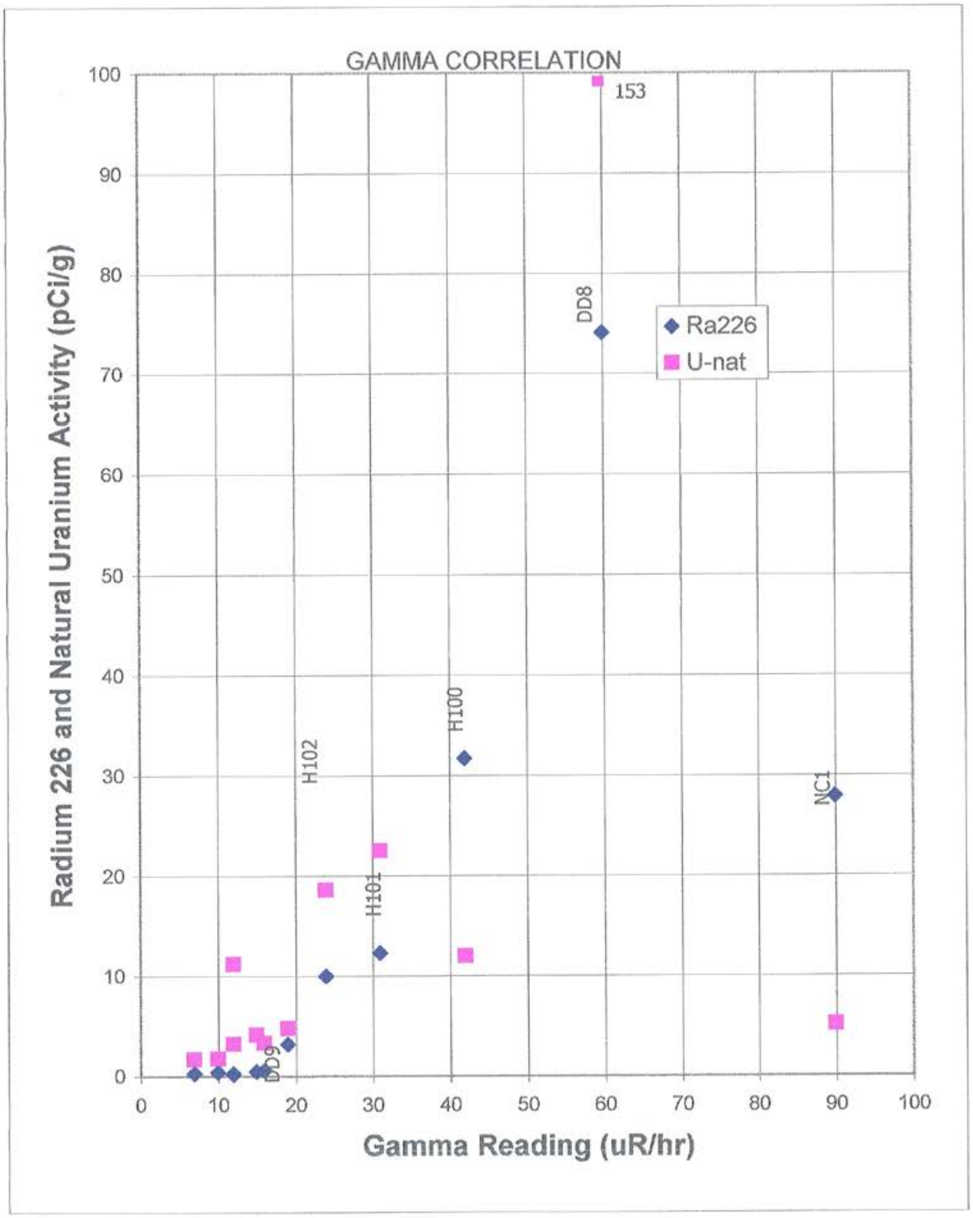


Figure 3-4. Radium 226 and Natural Uranium Activity Versus Gamma

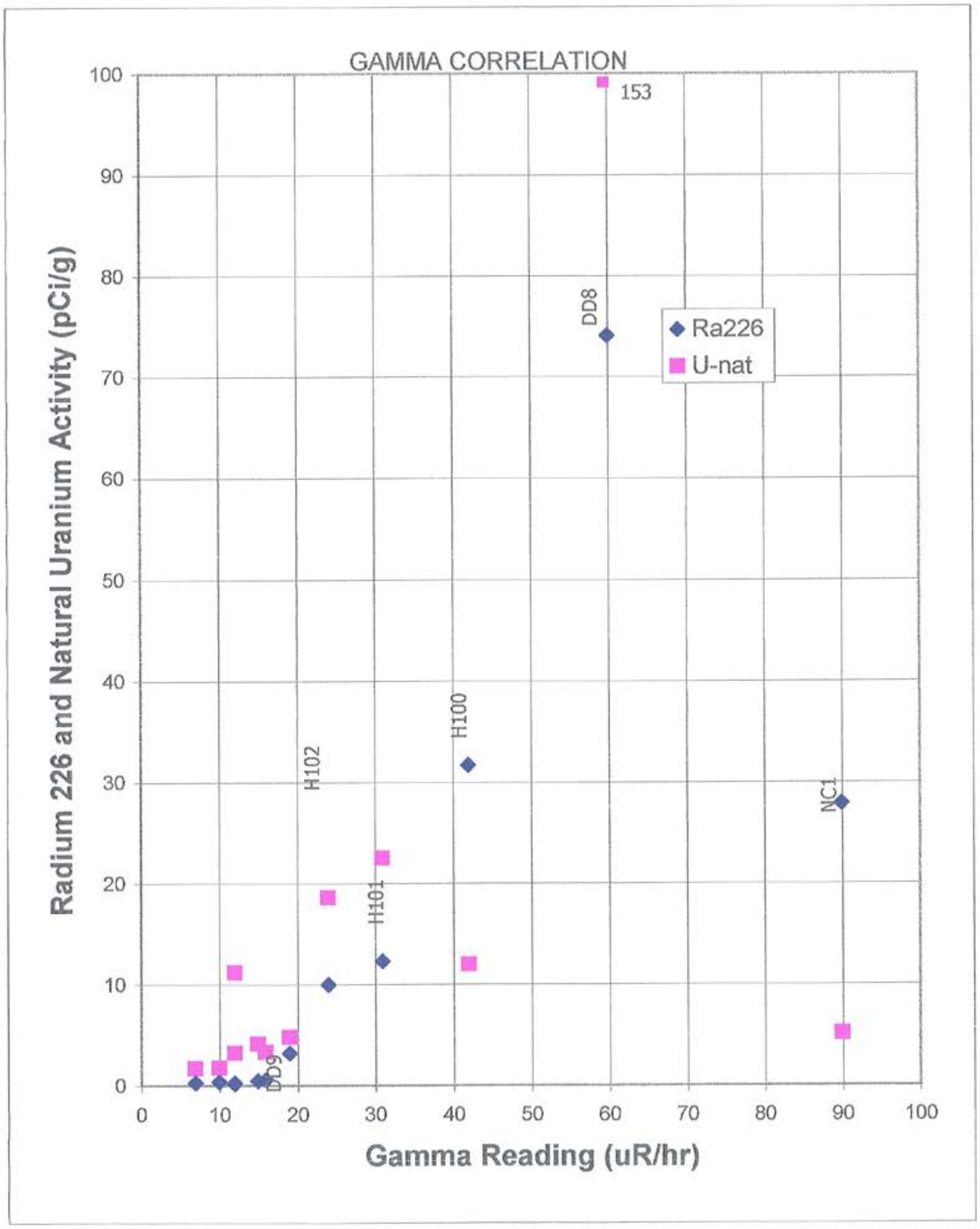


Figure 3-4. Radium 226 and Natural Uranium Activity Versus Gamma

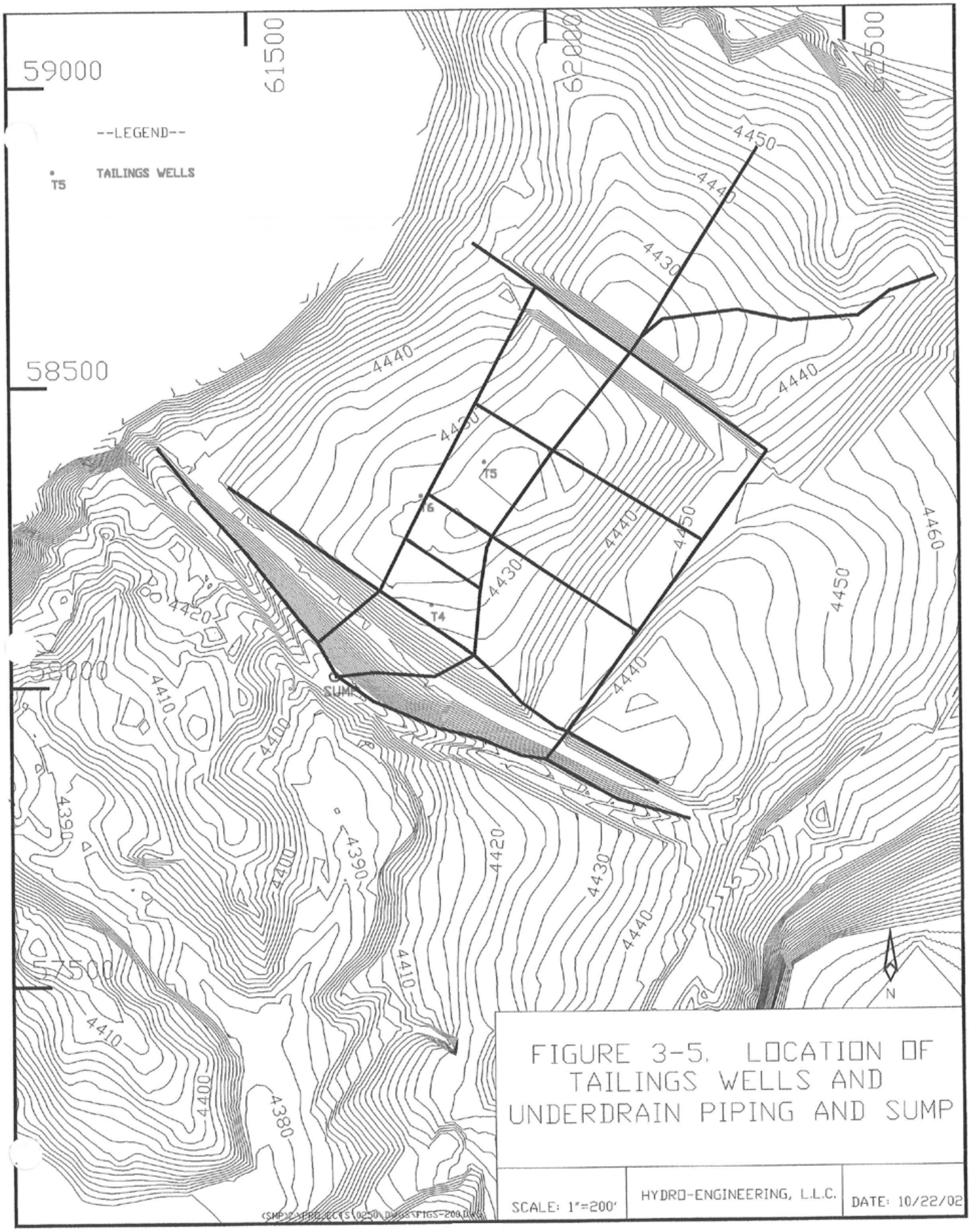


FIGURE 3-5. LOCATION OF TAILINGS WELLS AND UNDERDRAIN PIPING AND SUMP

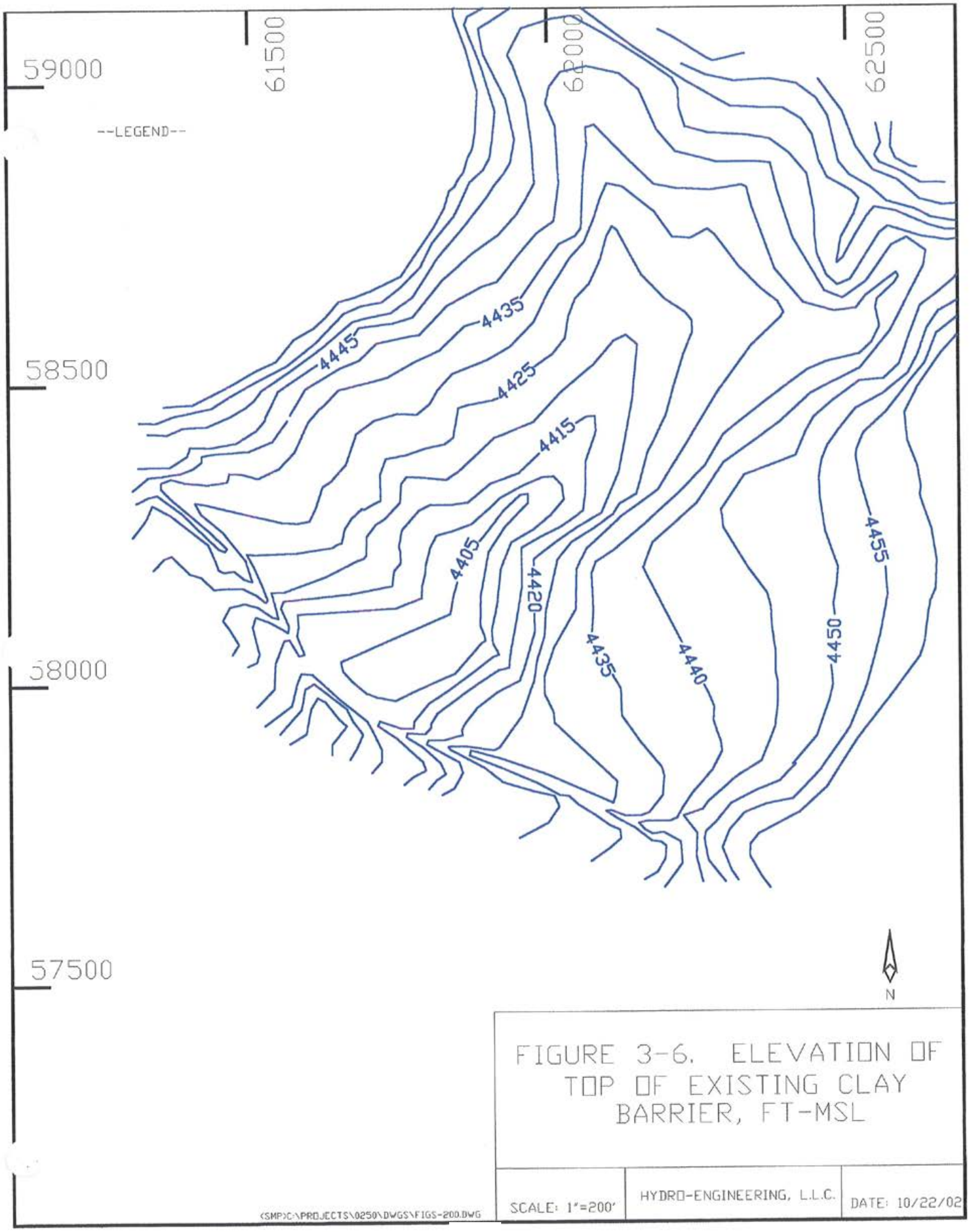
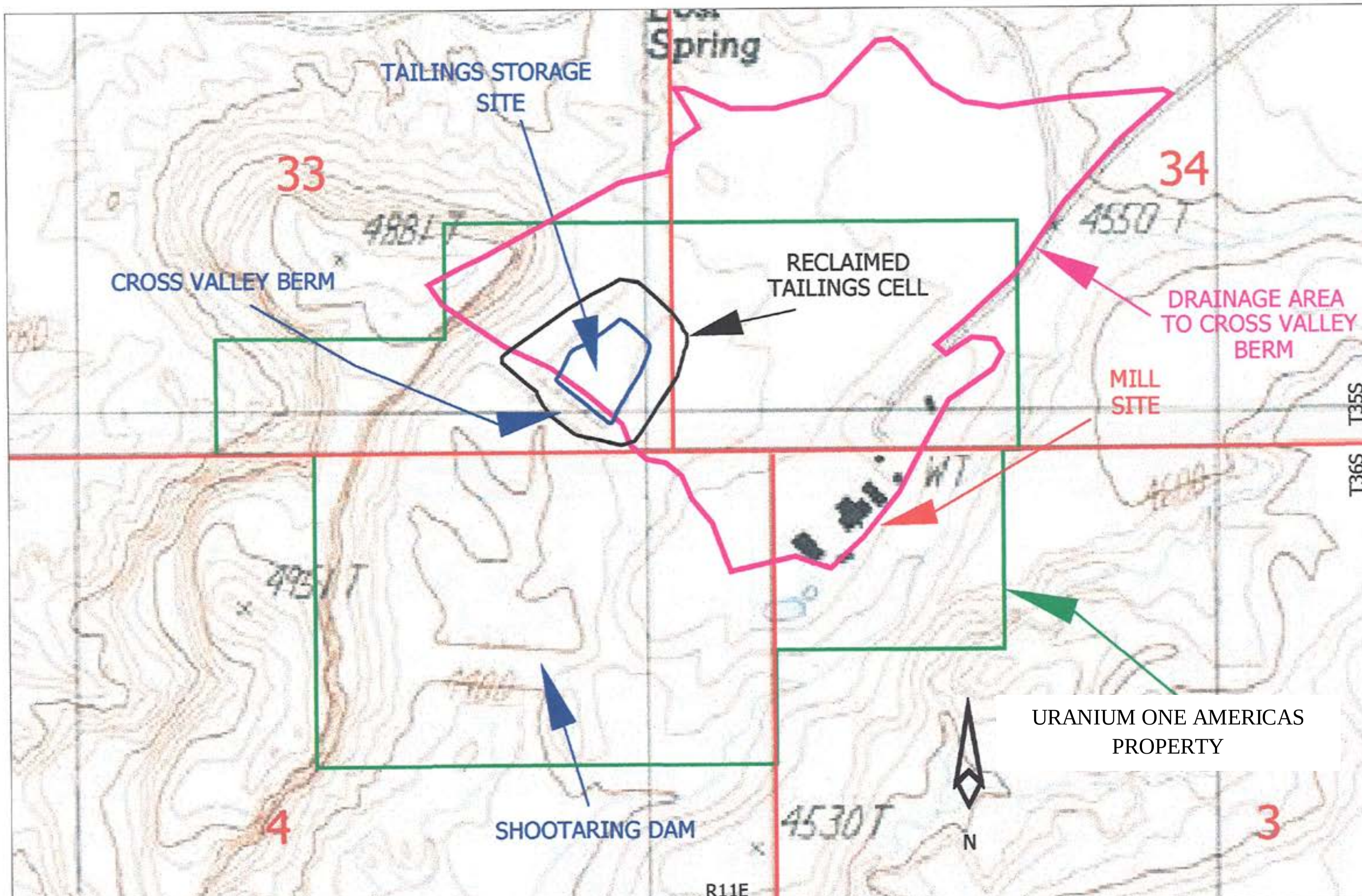


FIGURE 3-6. ELEVATION OF TOP OF EXISTING CLAY BARRIER, FT-MSL

SCALE: 1"=200'	HYDRO-ENGINEERING, L.L.C.	DATE: 10/22/02



SCALE: 1" = 800'

DATE: 02/21/2003

FIGURE 3-7. LOCATION OF DRAINAGE AREA AND DESIGN TAILINGS CELL disposal. Figure 2-1 shows the proposed Long-Term Care Boundary which includes the tailings cell and associated runoff channels. All of the land within this area is owned by Uranium One Americas (see Figure 2-3). Title and custody of the byproduct material (tailings), and the tailings disposal area, including any interests therein, will be transferred to the United States or the State of Utah, at the option of the state. As noted above, mineral rights are already owned by the United States (as to oil and gas) and the State of Utah (as to all other minerals). Uranium One Americas reserves the right to maintain, transfer, sell, or otherwise dispose of its property adjacent to the tailings disposal area.

2.2 History of Operations

Figure 2-1 shows the location of the Shootaring tailings and mill sites with topography. The mill was designed and constructed between 1978 and 1981. The facility operated for approximately five months in the summer of 1982, processing approximately 25,000 cubic yards of ore. All tailings were deposited in the existing lined tailings cell shown in Figure 2-1.

Historically, the project area has been used for seasonal livestock grazing and as wildlife habitat. Human use of the project area for activities, such as camping, hiking, sightseeing, and hunting, has been minimal to date in part because of the availability of other areas in southeastern Utah for these activities.

Limited livestock grazing and wildlife habitat will probably continue to be the principal use of the affected area after termination and closure of the project. Agricultural use of the area, for either crop or hay production, is not anticipated due to the poor soil structure and scarcity of water. There are presently no urban or industrial developments in the project area other than the facilities originally related to the project and a boat repair/storage yard. Future development of the property and released structures in and around the mill would most likely be for light industrial, such as boat storage.

Approximately 18 acres (7.25 ha) were leveled for construction of the plant, office, ore stockpile pads, plant buildings, and auxiliary structures. The surface gradient for runoff is sloped toward the tailings impoundment area. Filling was required over the balance of the graded area. Typically, cuts ranged from zero to about 15 feet (4.57 m) in depth except in localized areas (such as the ore dump pocket and connection conveyor tunnel) where excavation was as deep as 45 feet. Maximum fill depth was approximately 40 feet at the southwest comer of the ore
storage pad.

2.3 Geology and Hydrology of the Mill Site and Tailings Impoundment Area and Corresponding Tailings Impoundment Dam Design

Thorough investigations of the mil1 site and tailings impoundment dam were conducted by Woodward-Clyde Consultants prior to the design and construction of the facility. Investigations included demography, meteorology, hydrology of both the ground and surface water, the corresponding water uses, and regional and site geology. Woodward-Clyde documented their findings in Woodward-Clyde (1978a and 1979) for the design of the project. Woodward-Clyde (1978b) presents the tailings management plan while Woodward-Clyde (1980) presents the preoperational radiological environmental monitoring program. The mill was constructed in 1980 and 1981. Cross sections from the Woodward-Clyde (1982) as-built report are used in the reclamation plan to define quantities.

Another source for this information can be found in Uranium One Americas Source Material License Renewal Application SUA 1371, Docket No. 4-8698, Dated March 11, 1996, which was submitted previously to the NRC.

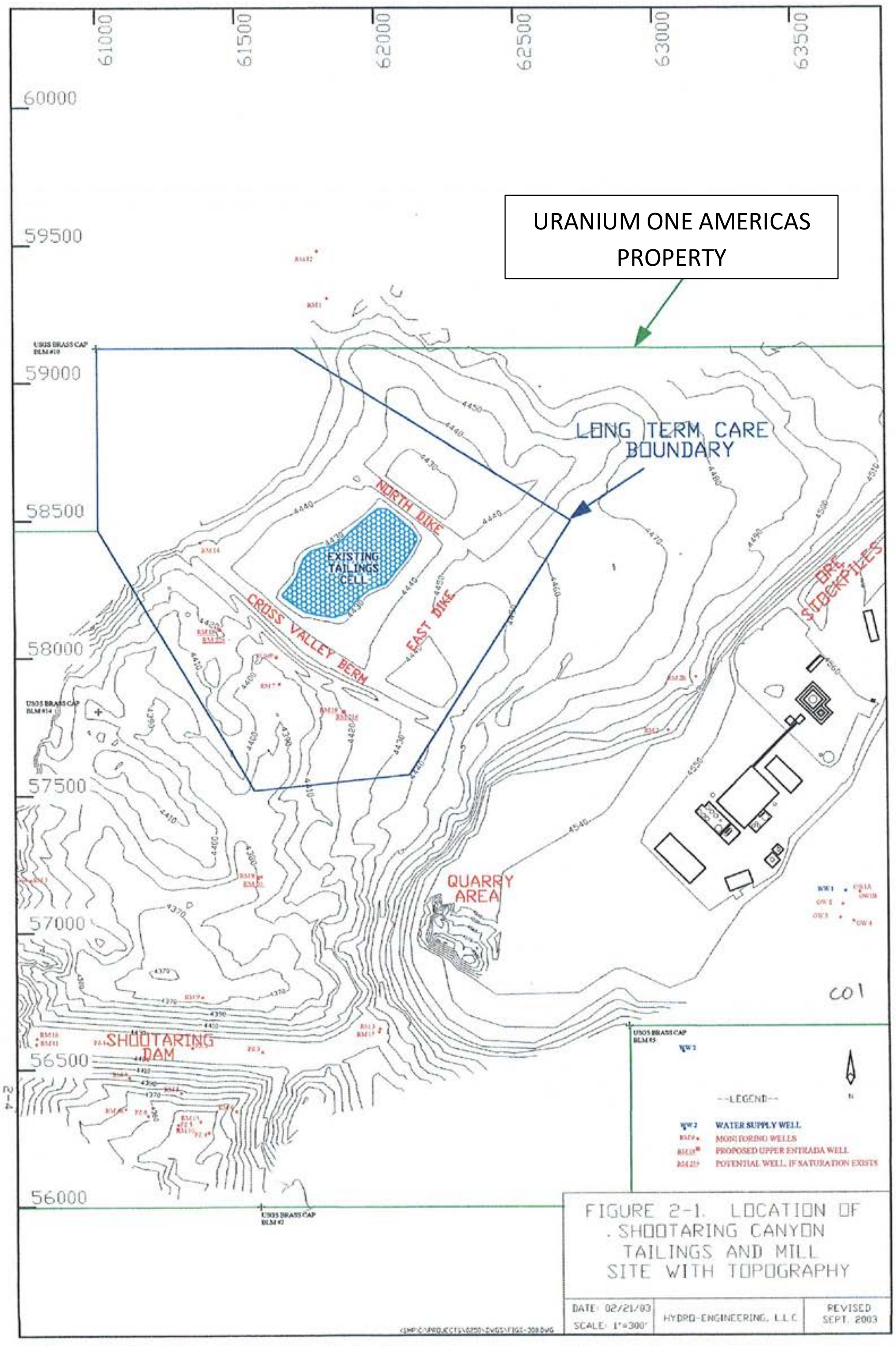


FIGURE 2-1. LOCATION OF SHOOTARING CANYON TAILINGS AND MILL SITE WITH TOPOGRAPHY

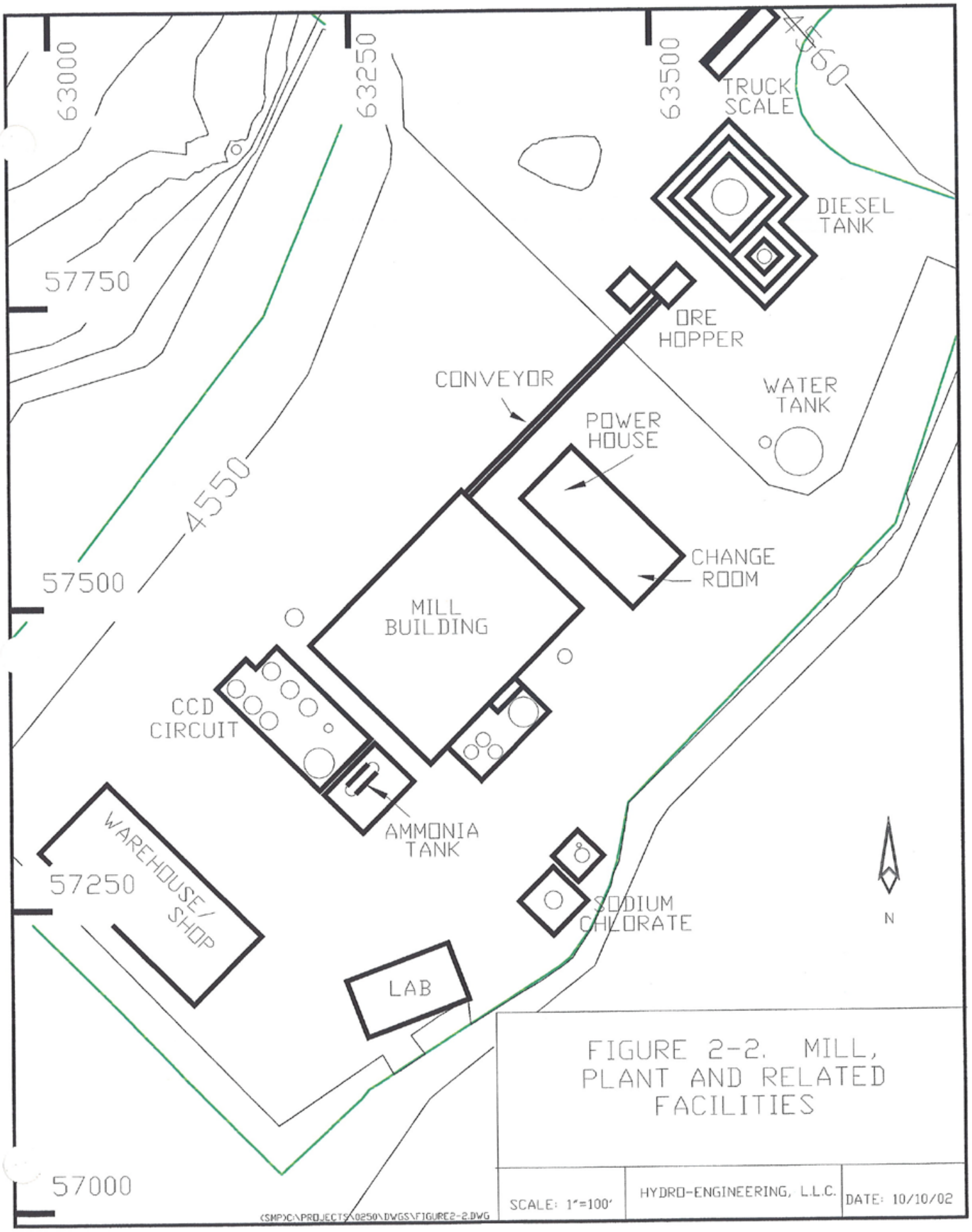


FIGURE 2-2. MILL, PLANT AND RELATED FACILITIES

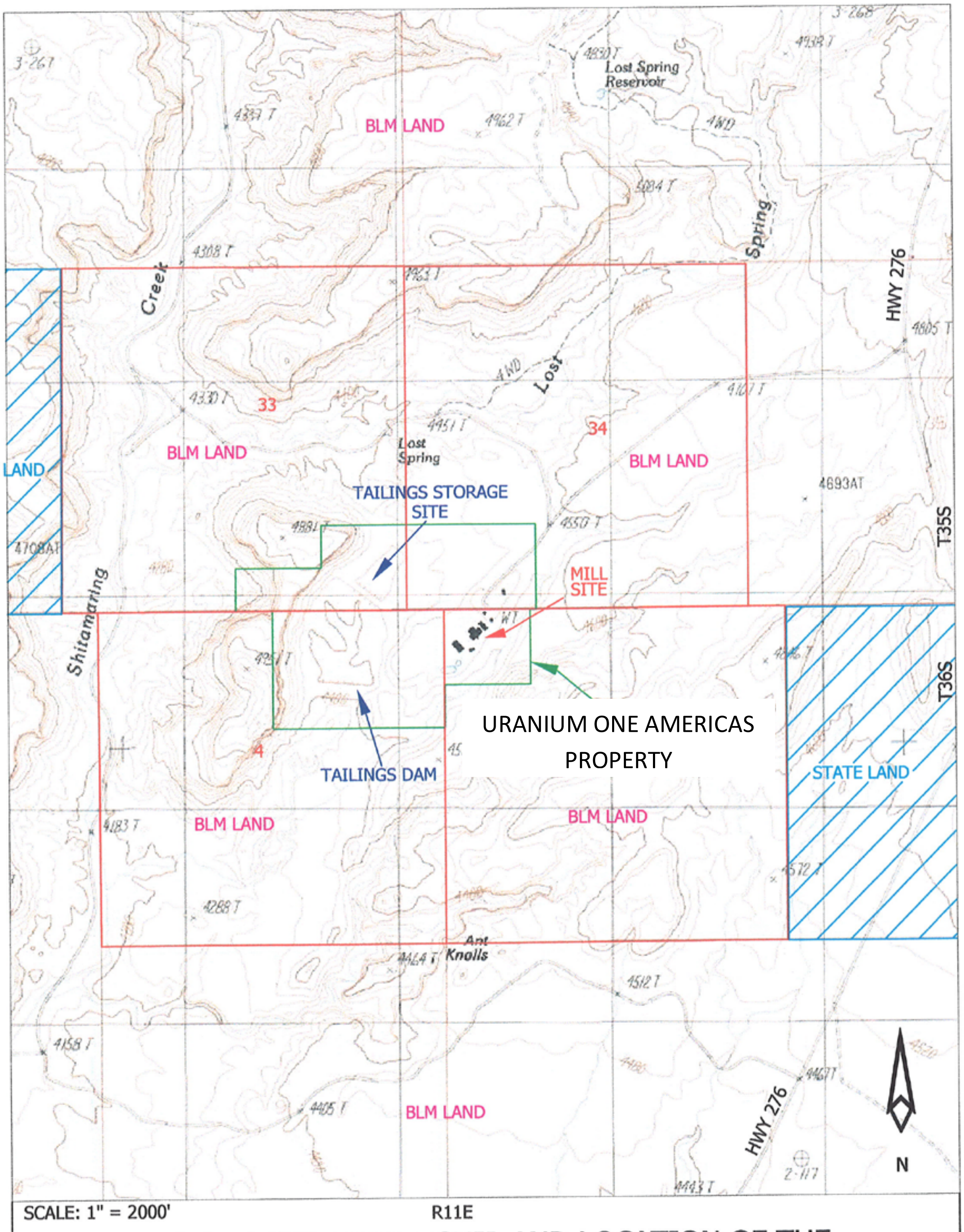


FIGURE 2-3. LAND OWNERSHIP AND LOCATION OF THE SHOOTARING TAILINGS AND MILL SITE

4.0 GEOLOGY AND SEISMOLOGY

A comprehensive summary for the Shootaring Canyon site of the geologic and seismologic setting and site and subsurface conditions was presented in previous reports and is generalized here. (Woodward Clyde Consultants, Environmental Report May, 1978c).

4.1 Regional Geology

The project site is located within the Colorado Plateau physiographic province in southeastern Utah. Wide areas of nearly flat-lying rocks separated by abrupt monoclinal flexures form the broad uplifts and intervening basins common to this province. Igneous intrusions have formed several mountains, such as the Henry Mountains near the facility. However, most of the topographic relief in the Colorado Plateau is the result of erosion of deep canyons rather than upstanding mountain ranges (Thornbury, 1965).

The Shootaring facility is located near the southern end of the Henry Mountains' structural basin. The basin contains sedimentary rocks ranging from Mesozoic to Cenozoic in age, and which are cut by the Tertiary intrusives forming the Henry Mountains, including Mt. Ellsworth, see Figure 4-1. The basin is elliptical, with its longer axis 100 miles in length trending northerly and its shorter axis 50 miles in length trending easterly. The basin is bounded on the west by the Waterpocket Fold (monocline) and on the east by the Monument Upwarp. Elevations within the basin range from 4000 to 7000 feet. Major peaks rise 4000 to 5000 feet above the surrounding basin. Fault development in the area is associated with the intrusive igneous centers of the Henry Mountains. These faults commonly have a northeasterly or northwesterly strike and do not generally extend far from the intrusive bodies. Faults are not known to exist within the project.

4.2 Site Geology and Geomorphology

The processing facility site is located in an area characterized by buttes, mesas and canyons approximately five miles southwest of Mt. Ellsworth (see Figure 4-2). The mill is situated on a low mesa and a small, isolated catchment to the west contains the tailings impoundment. A tall butte separates the site from Shootaring Canyon. Drainage from the site is to the southwest into Shootaring Creek. The tributary in which the tailings dam is located has been called Shootaring Canyon. Local relief ranges from 200 to 500 feet. Geologic structure is relatively simple in the immediate area, with the various sedimentary formations dipping gently (2 to 3 degrees) to the west. Sedimentary rocks exposed at the surface are predominantly sandstones of Upper Jurassic age. The high buttes and mesas west and north of the site are capped by the Salt Wash Member of the Morrison Formation. This fluvial sandstone unit contains the uranium deposits that are mined in the area. Exposed cliffs surrounding the buttes and mesas are comprised primarily of the thinly bedded reddish-brown siltstones and mudstones of the Summerville Formation, underlain by the generally massive fine grained reddish-brown Entrada Sandstone. The Entrada Sandstone is the bedrock underlying the mill and the tailings impoundment. In the vicinity of the site the Entrada is approximately 420 feet thick. Cementing agents are commonly calcite and ferric iron. Environment of deposition is believed to be primarily eolian. Subordinate amounts of shale are present locally, evidence of episodes of marginal marine conditions.

No major faulting has been observed in the Entrada Sandstone at the site. Limited sets of joints are widely spaced, steeply dipping and sealed with calcite and gypsum. Joint trends are northwesterly and northeasterly, coinciding with the regional structural pattern.

Beneath the Entrada lies the Carmel Formation, a heterogeneous unit approximately 160 feet thick composed of sandstone, siltstone, mudstone, limestone and gypsum. In the Shootaring Canyon area, the Carmel appears to include substantial layers of shale or mudstone. The Carmel is underlain by the Navajo Formation which is approximately 800 feet thick in the vicinity of the site. The base of the Navajo is approximately 1400 feet beneath the surface of the site. A typical stratigraphic section for the area surrounding the site is given in Figure 4-1.

Shootaring canyon is in the valley with narrow divides and therefore is in a mature geomorphic condition. The tailings cell is located in an upstream portion of a drainage basin which will need controls to prevent the erosional mechanisms that typically transport sediment from this region of the basin.

4.3 Seismicity

Earthquake activity in the region that may affect the facility site can be evaluated by examining the historical seismicity of the region. Figure 4-3 shows epicenter locations for 112 earthquakes reported between 1853 and January 1976 with magnitudes of 3.5 and greater, or Modified Mercalli intensities of V and greater, within a 200-mile radius of the site. Table 4-1 defines intensity ratings on the Modified Mercalli scale (MM).

Table 4-1. MODIFIED MERCALLI INTENSITY SCALE OF 1931

Intensity	Summary of Observed Effects
I	Not felt by people, except under especially favorable circumstances.
II	Felt indoors by a few people.
III	Felt indoors by several people.
IV	Felt indoors by many people, outdoors by a few people. Awakens a few individuals.
V	Felt indoors by practically everyone, outdoors by most people. Awakens most sleepers.
VI	Felt by everyone, indoors and outdoors. Awakens all sleepers.
VII	Frightens everyone. General alarm. Difficult to stand.
VIII	General fright, alarm approaches panic. Persons driving cars are disturbed.
IX	Panic is general. Ground cracks conspicuously.
X	Panic is general. Extensive damage to well-constructed buildings.
XI	Panic is general. Broad fissures, earth slumps, and land slumps develop in soft, wet ground. Damage to buildings is severe.
XII	Panic is general. Damage is total and practically all buildings are destroyed.

This scale was used in assigning earthquake intensities in Utah prior to the mid-1940's. Table 4-2 describes an additional eight events with magnitude of 3.5 and greater reported within the 200 mile radius between July 1978 and December 1983. Figure 4-4 shows epicenter locations for 94 earthquakes reported between June 1983 to January 1996 with magnitudes of 2.5 and greater within the 200 mile radius. Figure 4-5 shows epicenter locations for all earthquakes reported between 1853 and January 1996 with magnitudes greater than 0.

Table 4-2 LISTING OF FELT EARTHQUAKES WITH MAGNITUDE OF 3.5 OR GREATER-JULY 1978- DECEMBER 1983

Date	Time	Location	Magnitude
4/30/79	02:07:09.98	37N53.05 110W58.93 Southern Capitol Reef National Park	3.6
4/6/80	10:45:04.3	39N56.86 111W58.46 1 mile west of Elberta, Utah	3.5
5/24/80	10:03:36.47	39N56.21 111W57.59 near Elberta, Utah	4.4
2/1/81	02:21:47.67	37N33.82 113W15.83 near Kanarraville, Utah	3.6
4/5/81	05:40:39.69	37N35.49 113W17.87 near Cedar City, Utah	4.6
5/14/81	05:11:04.34	39N28.86 111W04.72 Hiawatha, Utah	3.5
5/24/82	12:13:26.56	38N42.50 112W02.19 near Richfield, Utah	4.0
12/9/83	08:58:40.72	38N34.62 112W33.93 near Cove Fort, Utah	3.6

Source: Richins, Wm. D. et al. 1981 and 1984 Earthquake Data for Utah Region, July 1978 to December 1980 and Jan. 1981 to Dec. 1983. University of Utah, Department of Geology & Geophysics, Salt Lake City, Utah

A persistent feature of the seismic history of the region is a broad band of activity trending NE-SW. This seismic belt coincides with the boundary between the Basin and Range and the Colorado Plateau physiographic provinces. The seismic activity associated with this belt is located more than 80 miles west of the facility. Seismicity in the nearest portion of the belt appears to be chiefly related to the Elsinore, Tushar and Sevier fault zones which bound the Sevier Valley. The interior of the Colorado Plateau historically exhibits a very low level of seismicity.

The largest recorded event depicted in Figure 4-3 had an epicenter about 110 miles northwest of the site and a maximum (MM) intensity of VIII to IX. Its magnitude was estimated at 6.7 (Cook and Smith, 1967). The event nearest the site had an epicenter about 20 miles southeast of the facility site. This earthquake, which occurred on August 22, 1986, had a magnitude of 4.0 on the Richter scale. The next nearest event occurred on September 20, 1963 and had an epicenter about 38 miles north of the facility with a magnitude of 4.5 on the Richter scale. Published curves relating ground motion intensity to distance from an earthquake's epicenter suggest that the maximum intensity that has occurred at the site is III-IV (MM) (Brazee, 1976). This level of intensity is not normally associated with structural damage (Richter, 1958). Based on the seismic history, the probability of a major damaging earthquake occurring at or near the site is remote. Algermissen and Perkins (1976) indicate a 90% probability exists that a horizontal acceleration of 4% of gravity would not be exceeded in 50 years. However, should such an acceleration level occur, only minor damage would be expected.

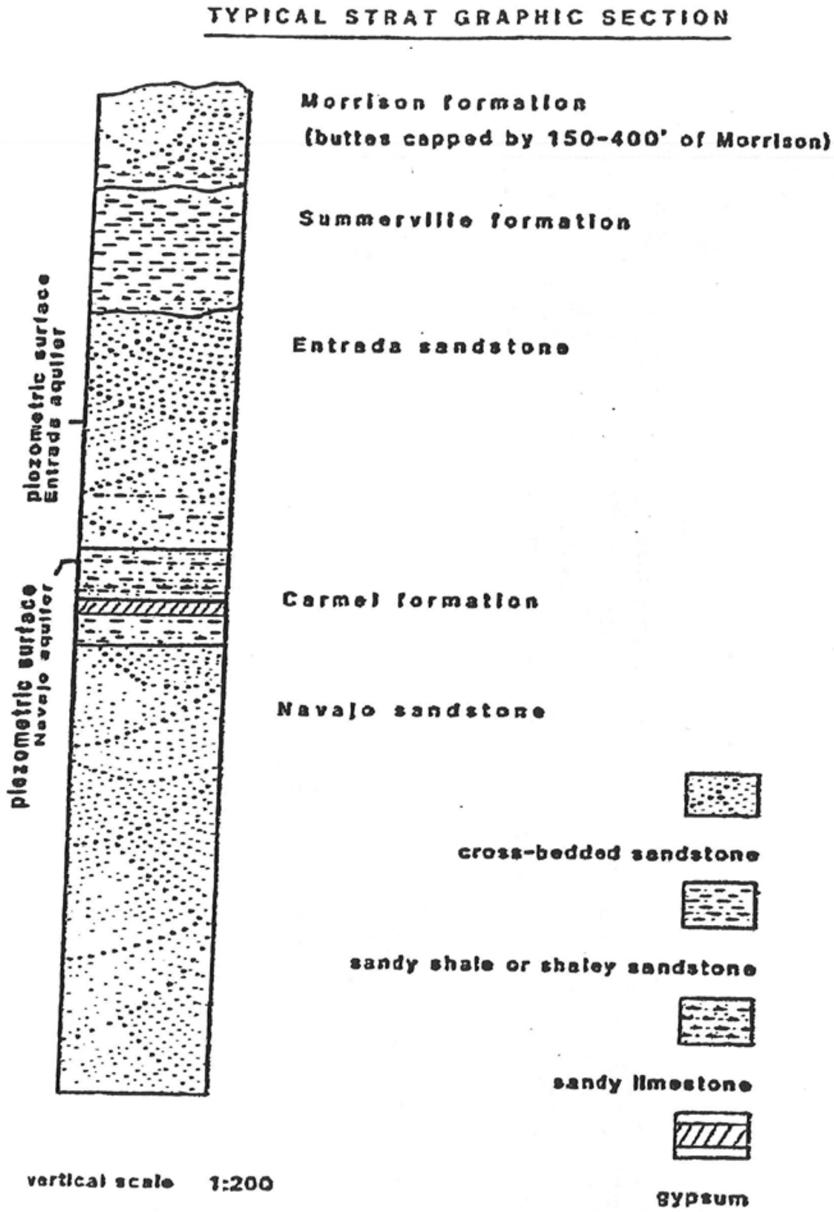


Figure 4-1. Typical Stratigraphic Section

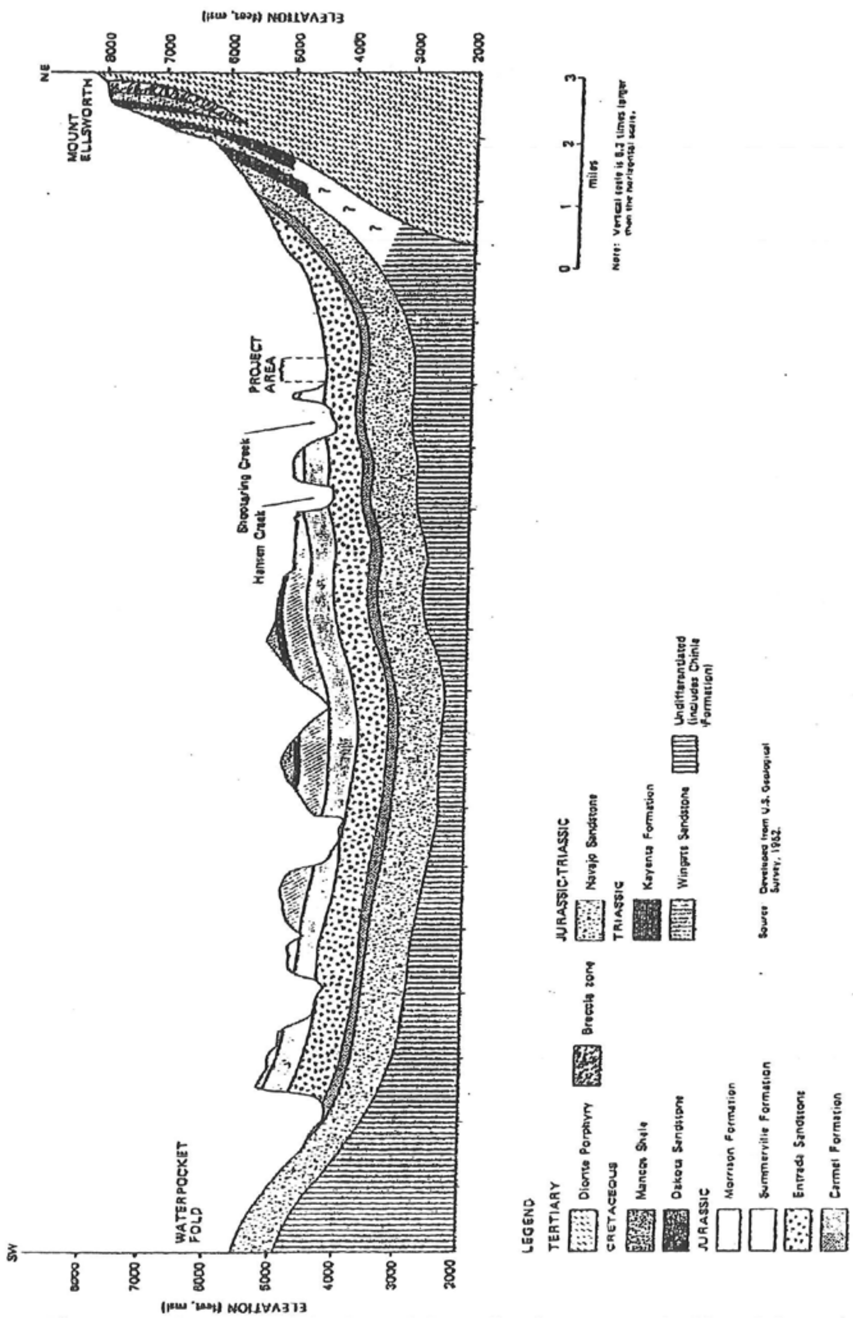


Figure 4-2. Generalized Geological Cross Section Across the Henry Mountain Basin

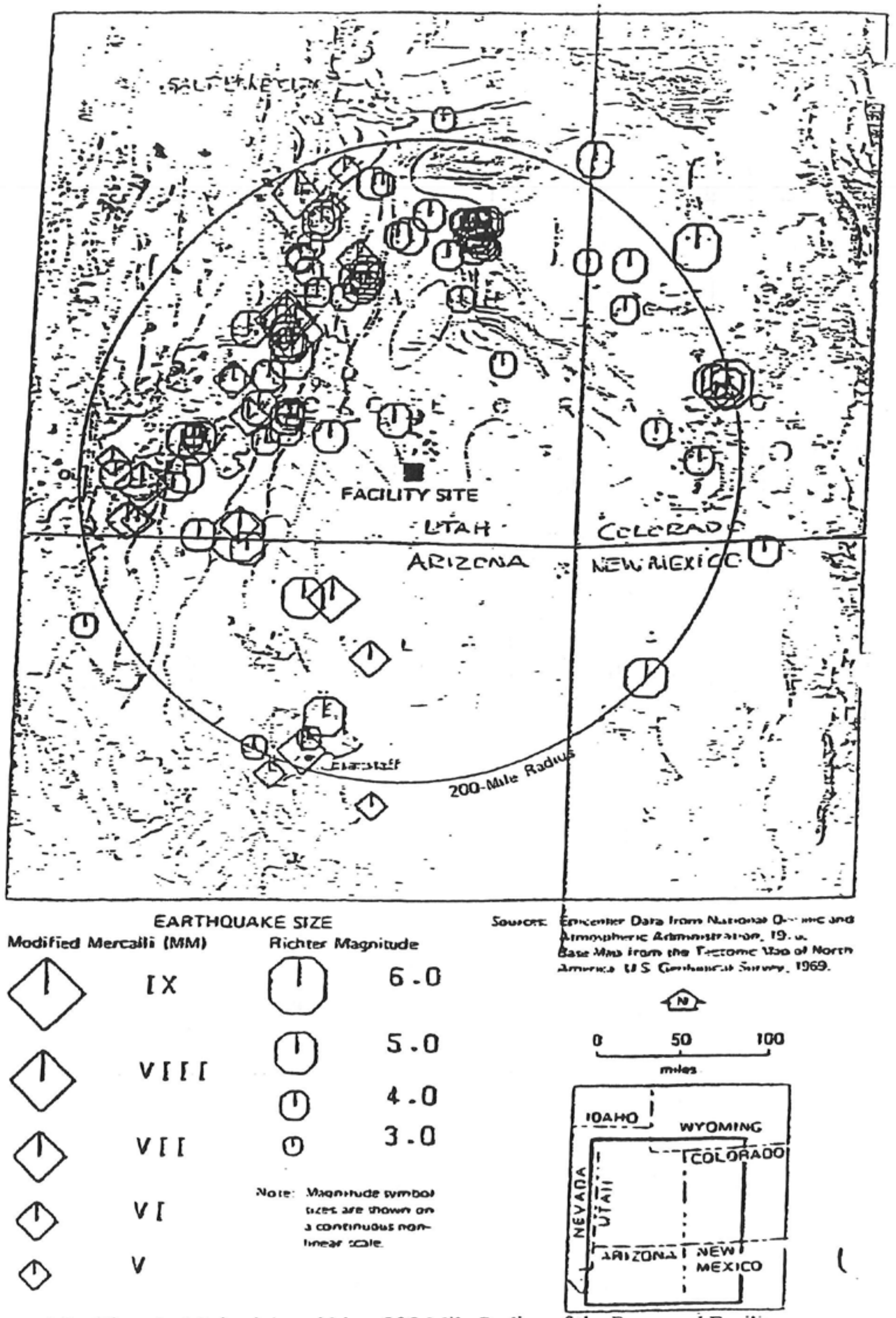


Figure 4-3. Historical Seismicity within a 200 Mile Radius of the Proposed Facility

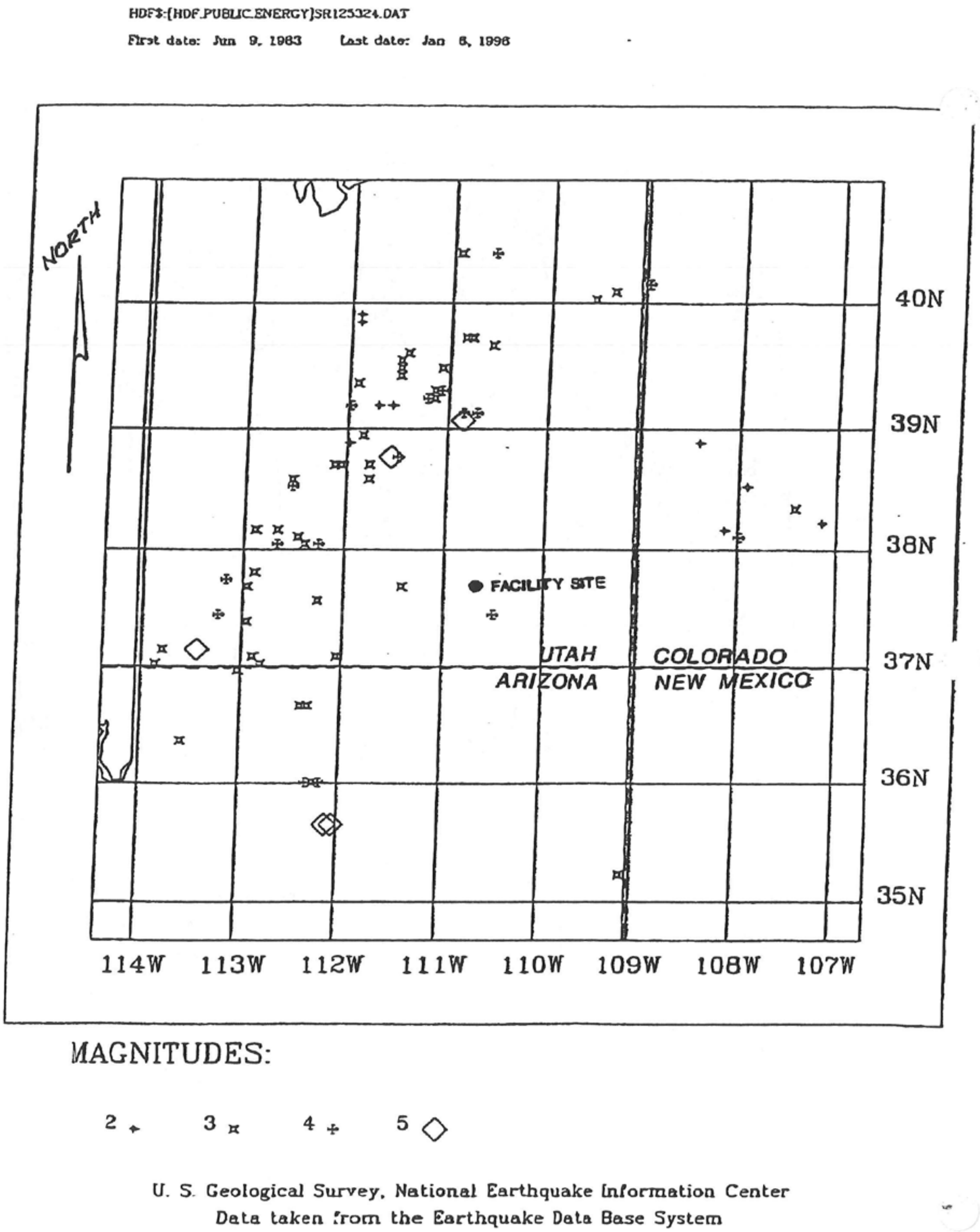
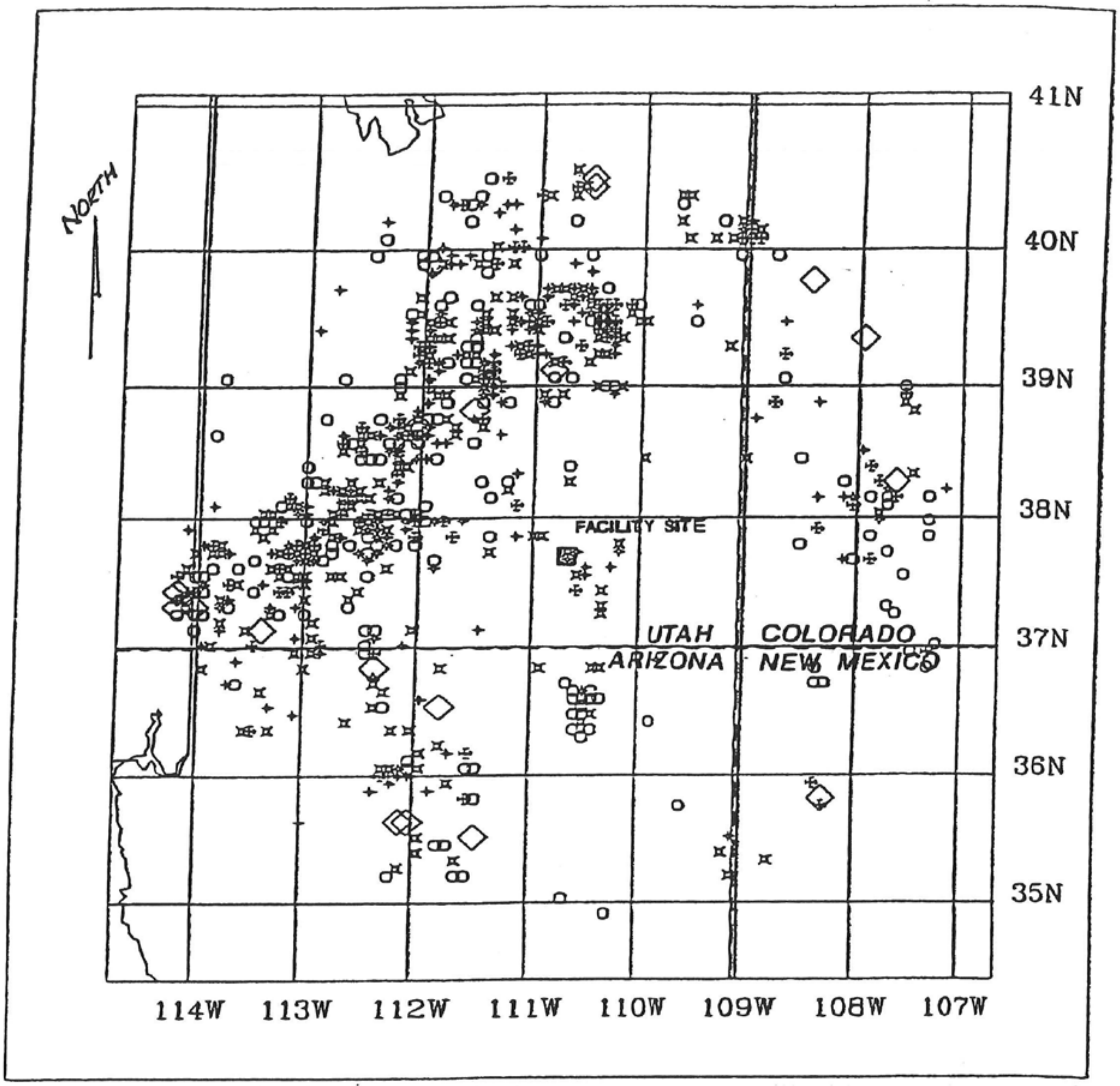


Figure 4-4. Epicenter Locations for Earthquakes, June 1983 to January 1996

HDFS:[HDF.PUBLIC.ENERGY]SR124731.DAT

First date: Dec 1, 1853 Last date: Jan 8, 1996



MAGNITUDES:

? o 1 □ 2 + 3 ⌑ 4 ÷ 5 ◇

U. S. Geological Survey, National Earthquake Information Center
Data taken from the Earthquake Data Base System

Figure 4-5. Epicenter Locations for all Earthquakes, 1853 to January 1996

5.0 GEOTECHNICAL STABILITY

5.1 Site and Uranium Mill Tailings Characteristics

The short operational period for the mill resulted in a very limited quantity of tailings which have been placed upstream of the cross valley berm (see Figure 2-1). There were no tailings placed between the cross valley berm and the Shootaring Canyon dam, and the majority of this area is also planned for release following reclamation. The present Shootaring Canyon dam will be almost completely breached to provide materials for the cover of the tailings. All contaminated materials will be encapsulated upstream of the toe of the reclaimed cross valley berm with a modest expansion of the current tailings cell.

5.1.1 Soil and Rock Properties

The fill, cover and rock materials that will be used in the tailings encapsulation system are locally derived. Three sources of rock were sampled including the quarry, rock on the Shootaring Canyon dam, and rock within the rocky soil cover currently lying above the clay liner and drainage system for the tailings cell upstream of the cross valley berm. The three sources of rock each consisted of a fraction of andesite porphyry and a fraction of sandstone. The fractions of each rock type within each source were very similar and it is obvious that the three rock sources have a common origin and are relatively similar. Only the quarry and rock from the dam will be used in the tailings reclamation. Multiple quality and gradation samples were taken from each rock source and the results are compiled in Appendix C. Petrographic analysis of both the porphyry and the sandstone were also performed. A detailed discussion of the rock quality and implications to the erosion protection are included in Section 6.4.1.

The quarry material contained a significant fraction of finer materials that is planned for use as the top layer of the cover. Material within the Shootaring Canyon dam designated as Zone 2 is expected to be very similar and the rocky soil cover also contains a similar fraction of finer materials. In addition to the cobble to boulder-sized stones within these materials, there is a substantial fraction of materials that ranges from gravel to silts and clays. This broad range of particle sizes makes this material very versatile for processing as cover material. The material can be processed to extract the rock in various gradations, thereby leaving a fine fraction for use as a frost barrier/vapor break cover for the tailings cell. This material will still contain enough sand and gravel sized particles to make it function as a bedding/filter material under rock mulch and small channel riprap. Substantial rock fractions can be retained in this cover material provided the layer thickness will accommodate the largest stone.

Additional soil materials that will be produced in the reclamation process include a very uniform fine sand that is generated from the Entrada sandstone which underlies the entire area. The sand produced by ripping and heavy equipment excavation of the sandstone is fine and extremely uniform. Large quantities will be generated by channel excavation, and this material will be used as an interim/grading cover beneath the clay barrier layer as well as for general fill. Gradations for this material are presented in Appendix C.

5.1.2 Clay Cover Properties

The clay that will be used for the radon/infiltration barrier in the tailings cap was imported and placed as the tailings cell liner and the Shootaring Canyon dam core. This clay was borrowed offsite and has been worked and previously conditioned. A variety of samples of this clay were taken from the in-place clay liner and the tailings dam (see Appendix C and Tables 5-l and 5-2). These samples were analyzed for a variety of physical properties (gradation, in-place density, moisture content, Atterberg limits, and Proctor density) as well as for hydraulic properties using both in-situ infiltrometers and laboratory permeability tests. The results indicated a consistently high quality clay that is suitable for use as the radon/infiltration barrier. Virtually all of the clay for the tailings cap will be taken from the clay core in the Shootaring Canyon dam. The clay in the liner system is very similar, but the clay core in the dam will provide a greater yield of clay with less disturbance. The properties of the clay relevant to the use as a radon/infiltration barrier are discussed in Sections 5.4 and 5.4.1.

TABLE 5-1. MOISTURE CONTENT RESULTS

SAMPLE SITE	SOIL TYPE	MOISTURE CONTENT (%)
NP11	CLAY	22.6
NP6	CLAY	29.9
NP5	CLAY	26.5
NP4	CLAY	24.9
NP10	CLAY	22.4
WP4	CLAY	32.3
NP6	ENTRADA SAND	2.5
T7	TAILINGS SLIMES	73.4
T3	TAILINGS SAND	9.63

SAMPLE FROM SAND CONE TESTS

SAMPLE SITE	SOIL TYPE	MOISTURE CONTENT (%)
NP11	CLAY	19.1
WP2	CLAY	28.1
NP2	CLAY	19.2
NP4	CLAY	22.3
NP11	CLAY	22.4
NP9	CLAY	20.9
CV5	ENTRADA SAND	2.17
CV2	ENTRADA SAND	2.55
ND4	11.e(2)	8.60
T3	TAILINGS SAND	3.06

TABLE 5-2. RESULTS OF SAND CONE TESTS.

TEST SITE	TEST SETTING	WEIGHT OF SAND BEFORE TEST (LBS.)	WEIGHT OF SAND BEFORE TEST (LBS.)	WEIGHT OF SAND IN CONE (LBS.)	WEIGHT OF MOIST SOIL (LBS.)	MOIST UNIT WEIGHT OF SOIL (LBS/FT^3)	MOISTURE CONTENT (%)	DRY UNIT WEIGHT OF SOIL (LBS/FT^3)
WP1	ON CLAY IN BACKHOE PIT	13.78	6.03	3.92	3.03	75.6	19.1	61.1
WP2	ON CLAY IN BACKHOE PIT	13.14	7.63	3.92	1.62	97.3	26.1	70.0
NP2	ON CLAY IN BACKHOE PIT	9.86	4.01	3.92	2.03	100.4	19.2	81.2
NP4	ON CLAY IN BACKHOEPIT	9.37	3.59	3.92	1.54	79.1	22.3	61.4
NP11	ON CLAY IN BACKHOE PIT	9.91	4.11	3.92	1.64	83.3	22.4	64.6
NP9	ON CLAY IN BACKHOE PIT	8.6	2.6	3.92	2.07	95.0	20.9	75.2
CV5	ON ENTRADA RED IN BACKHOE PIT	8.99	2.7	3.92	2.2	88.6	2.11	86.7
CV2	ON ENTRADA RED IN BACKHOE PIT	9.53	3.88	3.92	1.74	86.1	2.55	83.9
ND4	ON 11.e(2) IN PIT ON NORTH DIKE	10.01	3.35	3.92	3.08	107.4 *(2" rock in sample)*	8.60	98.1
T3	ON TAILINGS SAND TAILINGS CELL	9.07	3.14	3.92	1.95	92.6	3.06	89.8

5.2 Slope Stability

Past investigations to evaluate the stability of the Shootaring Canyon dam have revealed that this structure was competent. However the question about the Shootaring Canyon dam has been rendered moot because the dam has never impounded tailings and will be breached in the reclamation configuration. The final tailings reclamation plan calls for substantial reconfiguration of the cross valley berm, and in combination with virtually no saturation in tailings above the structure, this should make this a stable facility. The steepest portion of the current outslope of the cross valley berm is at approximately a 1.2H:1V slope with a crest of approximately 4448 feet above MSL. In the reclamation configuration, the crest will be graded inward to produce a drainage divide that is approximately 100 feet inboard of the current crest. The berm outslope will also be reduced to a maximum slope of 5H:1V. This post-reclamation configuration removes roughly the upper one-half of the cross valley berm and virtually eliminates its significance as an impoundment structure. Figures 9-9, 9-10 and 9-11 illustrate the dramatic alteration of the cross valley berm in the reclamation.

A drain system was installed above the clay liner and this system discharges to a sump downstream of the cross valley berm. The drain and liner system extends well beyond the cell where the tailings are deposited, so the drain system also captures runoff to the depression outside of the actual tailings disposal cell. The drain system has allowed rapid dewatering of the tailings following the shutdown of the mill. Wells were recently installed in the tailings and are dry. The discharge from the drain system has been at a very small rate for several years, reflecting the long-term infiltration rate through the interim cover and the capture of runoff from the lined but unused portion of the tailings cell. With the extensive drain system and the passage of approximately 20 years since tailings were placed in the facility, the tailings are dewatered and the saturated thickness above the clay liner is likely limited to a few inches, if any. Occasional spikes in the discharge rate are due to the rapid reporting of runoff to the drain system in areas where no materials have been placed on the drain and liner system.

The combination of very limited saturation within the tailings and the slope reduction and attendant height reduction of the cross valley berm have eliminated concerns for the questionable stability of the berm as an impounding structure. The reclamation configuration relegates the lower portion of the cross valley berm to general fill within a reclaimed tailings pile.

5.3 Liquefaction Potential

There is no potential for liquefaction of the tailings placed in the natural depression and retained behind the cross valley berm. As discussed in the preceding section, the tailings have been dewatered and the tailings have been present in the cell in a dewatered state for two decades. The addition of the clay cap will greatly reduce the surface infiltration. The maximum thickness of tailings is approximately 18 feet and the top of the tailings surface in the center of the existing cell is typically 20 to 25 feet below the eventual reclamation surface. The additional fill to bring the existing surface to the reclamation surface consists of contaminated materials (primarily ore) and the cover and erosion protection layers. With the bulk of the fill as ore which will be placed with some moisture conditioning to facilitate compaction and control dust, the entire fill thickness will be at a moisture content dramatically less than saturation. Liquefaction of these materials is extremely unlikely.

5.4 Cover System Design

Four materials are considered in the construction of the cover for the tailings and other contaminated materials. The primary material is the clay that is present in the core of the Shootaring Canyon dam. The second material, rocky soil, is the smaller fraction of the run-of-mine materials from the quarry area or the corollary Zone 2 material in the Shootaring Canyon dam. This material is planned for usage above the clay layer as a protective layer (frost penetration/vapor break) and will also serve to reduce radon release. The third material is non-specific in that it is planned as an interim cover/grading layer beneath the clay layer. This material may consist of the fine sand produced by excavation within the Entrada sandstone, reject clay materials encountered in channel excavation or borrow from the dam, or other similar non-contaminated materials encountered in the construction. The fourth material is the erosion protection layer consisting of rock mulch. This material is not considered part of the radon/infiltration barrier and is discussed in Section 6.

5.4.1 Clay Cover

The clay for the cover system will be borrowed from the Shootaring Canyon dam. The average moisture content for samples of the in-place clay was 24.2% (see Table 5-l). A typical dry density of the in-place clay is 70 lb/ft^3. The maximum dry density of existing clay liner and dam core, as determined by the Proctor method, ranges from 90.4 to 97.4 lb/ft^3 (samples NP-6, NP-1 0, NP-11, DA1 and C-4) with an optimum moisture content ranging from 25.4% to 30.8%. The percentage of clay samples passing the #200 screen ranges from 82.8% to 88.4%.

The specifications for the clay for the radon modeling are a minimum dry density of 90 lb/ft^3 and a minimum percentage passing the #200 screen of 75%. The average in-situ moisture content of 24.2% is used in the modeling and with an assumed particle specific gravity of 2.65, the porosity is approximately 46%.

5.4.2 Soil and Rock Cover

The rocky soil cover will be derived from quarry area or dam zone 2 material that is processed to remove rocks for rock mulch or riprap or to remove rocks too large to be placed within the cover layer. Gradations for these run-of-mine type materials as well as a sample of the fines are presented in Appendix C. When just the fines (<0.5 inch) are considered, there is an appreciable clay and silt fraction within the material (approximately 10%). The final gradation of this rocky soil cover will depend in large part on the type and gradation of rock products that are removed to produce rock mulch and channel riprap. At a minimum, the stones larger than *9* inches will be removed from this cover material to facilitate placement as cover. If the material is processed to produce a rock mulch, the upper limit of the cover gradation will be gravel sized particles. The presence of stones approaching 9 inches in diameter within the cover layer is not expected to have a detrimental effect on the function of the material as cover. In addition to functioning as a protective layer for frost penetration, a competent stone placed with a completely surrounding soil matrix reduces the pore space available for radon transport. For the purposes of radon emanation modeling, the soil cover will be assumed to have a density of 99 lb/ft^3 and a porosity of 40%. The long-term moisture content is estimated at 8% to reflect the presence of the silt and clay fraction.

5.4.3 Unspecified Cover Materials

The fine uniform sand produced by excavation of the Entrada sandstone and clay that was placed just east of the tailings cell during liner construction are two materials under consideration for interim/grading cover and general fill within the tailings cell. The Entrada sandstone is expected to require ripping and additional heavy equipment effort for excavation. Significant volumes of the sand will be generated during the construction and a part of this may be used on the tailings surface before the clay cover is constructed. Likewise, a clay source (represented by sample C-4) is available for use as this interim/grading cover. This clay was placed beside the tailings cell during liner construction and has properties that are similar to the dam and liner clay. However, this clay has been exposed to the elements since it was placed and there has been some inferior material deposited on the surface. With a smaller clay thickness and introduction of other materials, it is more cost effective to use clay from the dam for the clay barrier. For the purposes of radon emanation modeling, both materials will be considered for this interim/grading cover. The sand will be assumed to have a density of 99 lb/ft^3, a porosity of 40%, and a long-term moisture content of 6%. The interim cover clay will be assumed to have a density of 90 lb/ft^3, a porosity of 46%, and a long-term moisture content of 12%. This moisture content is reduced from that for the barrier clay cover to reflect a less rigorous construction and clay quality specification.

5.4.4 Ore Properties

The ore stockpiles will be placed within the tailings cell and will constitute less than half of the additional contaminated materials within the cell. A significant thickness of the ore (typically 8 to 12 feet) will overlay the tailings and will be the predominant radon source. Unfortunately the radium-226 activity of the ore is much greater than that of the tailings. The average radium-226 concentration of 30 ore samples is 225.68 pCi/gm (rounded to 226 pCi/gm). The average tailings radium concentration is 78.8 pCi/gm. Since the ore material has not been processed through a mill, secular equilibrium was assumed and the measured radium-226 activity is appropriate for use in radon release modeling. The radiological properties of the ore, tailings and other materials are presented in Table 3-1. Gradations of samples from the ore stockpile area are included in Appendix C.

5.4.5 Radon Release Modeling

The RADON model described in NRC Regulatory Guide 3.64 (1989) was used to predict radon release at the surface of the cover. The tailings cover system is shown in Figure 5-1, and the radon-222 flux predicted by the RADON model was limited to less than 20 pCi/m^2/sec. The rock mulch erosion protection was not included in the RADON modeling. The properties of the ore radon source and cover materials were discussed in preceding sections and are summarized in model results presented in Table 5-3. The radium-226 activity of the clay was measured on the C4 and NP4 samples and both were 0.5 pCi/gm and are less than background. A value of zero was used in the modeling for the cover material. The default emanation coefficient of 0.35 was used for all layers. Two scenarios were considered with the properties of the interim/grading cover changing from fine sand to clay to allow a variety of materials to be used for this layer.

The radon-222 flux was limited to less than 20 pCi/m^2/sec for both scenarios. In order to be conservative in the modeling of the radon release, the entire 5-meter thick source was assumed to be made up of the ore which had a larger radium-226 activity than the tailings. This ore was assumed to have a long-term moisture content of 8%, a dry density of 99 lb/ft^3, and a porosity of 40%. The thickness of the ore and the tailings will taper dramatically on the edges of the covered area and the southern outslope of the reclaimed tailings cell. This has not been incorporated into the flux model and thus leads to a conservative average flux.

TABLE 5-3. RADON MODELING RESULTS

Layer	Thickness (em)	Thickness (in)	Moisture Content (%)	Dry Density (g/cm^3)	Dry Density (lb/ft^3)	Porosity (%)	Radium 226 Activity (pCi/gm)	Emanation Coefficient	Radon Flux (pCi/m^2/s)
Scenario #1									
Cover	61	24	8	1.59	99	0.40	0	0.35	14.88
Clay Cover	45.7	18	24	1.44	90	0.46	0	0.35	17.40
lnterim Sand	30.5	12	6	1.59	99	0.40	0	0.35	39.59
Ore	500	197	8	1.59	99	0.40	226	0.35	94.12
Scenario #2									
Cover	61	24	8	1.59	99	0.40	0	0.35	14.46
Clay Cover	45.7	18	24	1.44	90	0.46	0	0.35	16.90
Interim Clay	30.5	12	12	1.44	90	0.46	0	0.35	38.47
Ore	500	197	8	1.59	99	0.40	226	0.35	92.76

The thickness of the cover system exclusive of the rock mulch is 54 inches. The first layer above the ore is a 12-inch thick grading/interim cover layer of fine sand (scenario #1) or clay (scenario #2) with properties as described in Section 5.4. 3. The predicted radon release for scenario #1 is 14.88 pCi/m^2/s and the predicted radon exit flux for scenario #2 is 14.66 pCi/m^2/s. The similarity in release with the two types of materials for the grading/interim cover leads to the observation that properties of this layer are not critical to the radon barrier performance. An additional RADON model run was conducted using the average ore radium-226 activity plus one standard deviation of 71.61 pCi/gm to produce source activity of 297 pCi/gm. With all other material properties set to the same values as scenario #1, the predicted radon exit flux was 19.55 pCi/m^2/s. This additional simulation indicates that the radon barrier is robust enough to absorb variability in the properties of the radon source. With the recognition that the scenario # 1 and scenario #2 simulations were conducted for critical areas of source term thickness and activity, the actual radon release through the cover should be significantly lower than the 20 pCi/m^2/s limit.

5.4.6 Dewatering and Settlement

The tailings disposal area is unique in that a very limited depth (maximum of approximately 18 feet) and quantity of tailings and interim cover was placed in a cell with an elaborate drainage system and no tailings have been added to facility for 20 years. The combination of these three factors has produced a tailings cell that has been essentially dewatered for a decade or more with a very limited expected magnitude of settlement. The drainage system and dewatering status are described in Section 5.2 with the conclusion that the tailings are dewatered. The area of the mill tailings cell is relatively small (approximately 3 acres) and there is very little distinguishable segregation of the tailings materials that typically occurs with larger tailings cells. This tailings cell is simply too small and the tailings are not thick enough to have developed the extensive segregation that occurs in larger cells with an established pool area. The slime layers detected in the drilling and backhoe sampling were very thin and constituted only a small fraction of the tailings profile. This combination of factors leads to the conclusion that ongoing tailings settlement is likely to be immeasurably small. With the elaborate drainage system and the small thickness of tailings, consolidation occurred very rapidly following elimination of the solution from the tailings cell. A large thickness of material will be placed over the tailings cell and will dramatically change the loading condition within the tailings during reclamation of the tailings. However, with no perceptible saturation in the tailings and a very favorable drainage condition, further consolidation of the tailings in response to the loading is expected to occur so rapidly that it will be essentially complete by the end of construction. The majority of the fill constituting the loading will be ore. This material will be placed in layers of 8 inches or less and compacted by wheel rolling or other means. The ore will be conditioned to a moisture content of 10% to 25% to control dust and to facilitate compaction. Ultimately, potential differential and total settlement during and following construction is so small that no impacts on the cover system are expected. Placement of monuments for monitoring of settlement prior to the placement of the cap was considered, but given the dewatering and consolidation status of the tailings, differential settlement is expected to be insignificant. A period of monitoring prior to placement of the clay barrier would leave the tailings cell in an incomplete and vulnerable state. Surrounding areas of excavation would also be left in a condition susceptible to erosion while awaiting completion of the erosion protection system.

5.4.7 Infiltration

The infiltration of water into and through the tailings will be limited by construction of the clay radon/infiltration barrier. This 18-inch thick clay cover will be constructed from the clay that was used in the dam core, which was from the same source as that used in the clay liner for the tailings cell.

Seven double ring infiltrometer tests were conducted on clay in the liner system and three laboratory permeability tests were conducted. The results of the testing are included in Appendix C. Although infiltrometer tests are not ideal for very low permeability materials (particularly in an environment with extremely high evaporation), they represented an opportunity to test the clay Iiner in place. The infiltrometer tests were conducted by excavating through the rocky soil cover to the clay in areas surrounding the tailings cell and installing the infiltrometers in the clay liner. In the first tests, a siphon arrangement was used to supply the infiltrometer and maintain a constant water depth in the inner ring. This was unsuccessful because the siphon system was not reliable and the infiltration rate was so low that resolution in the supply system was not adequate. The WP-1 infiltrometer test is an example of one in which the failure of the siphon system compromised the results. In subsequent tests, the depth of water in the rings was monitored and the change in water level was plotted as a function of time. The infiltration rate was very low and with a typical starting depth of water of 4 to 5 inches, none of the infiltrometers required addition of water to the inner ring and the final depth to water was typically 3 to 4 inches. Despite the improvement of reliability and resolution with direct measurement of depth of water, a diurnal cycling of the infiltration rate was observed and this was attributed to evaporation. Two evaporation tests were established by setting sealed caps with similar surface areas adjacent to two of the infiltrometers. All of the infiltrometers and the two evaporation cells were covered to minimize evaporation. Most of the infiltrometer tests were conducted for a period approaching three days and the weather conditions of the test period were extremely high air temperature (up to 108 degrees F) with low humidity and a moderate breeze.

With the cycling of the apparent infiltration and the very small changes in water depth in the rings, the response as shown in the figures in Appendix C does not exhibit the classical asymptotic approach to the saturated hydraulic conductivity. Rather, the plots of infiltration rate versus time are similar to a step function with rates, after a certain time (typically about 1 day or 1440 minutes), exhibiting the diurnal cycling but no discernible trend. For this reason, an average infiltration rate was determined for measurements after the trends were no longer present, and this was considered the apparent saturated hydraulic conductivity. For the six tests that produced usable results, the saturated hydraulic conductivities (more often referred to as the permeability) ranged from 2.37E-6 cm/sec to 4.90E-7 cm/sec. The two evaporation tests produced drops in water level that corresponded to rates of 2.58E-6 cm/sec and 8.92E-6 cm/sec. When the first interval rate is removed, the evaporation test rates were reduced to 1.27E-6 cm/sec and 2.11E-6 cm/sec. The evaporation tests actually produced rates that were greater than the measured infiltration rates. This indicates that the biasing of the infiltrometer results by evaporation is dramatic. It is likely that virtually all of the apparent infiltration can be attributed to evaporation and that the true permeabilities of the in-place clay are much lower than indicated by the infiltrometer tests. This is supported by the laboratory permeabilities of 3.4E-8 cm/sec for sample NP-6 and 6.5E-8 cm/sec for sample NP-10. A test was also conducted on sample C-4 with a resulting permeability of 4.4E-7 cm/sec. This sample was taken from the uncovered clay area where adulteration of the surface materials is likely and the quality of the clay has been slightly reduced by exposure and weathering. The data indicate a best estimate of the clay permeability of 5E-8 cm/sec based on the two laboratory permeabilities. A permeability of l .OE-7 cm/sec is considered a very conservative expectation of clay permeability placed at a minimum density of 90 lb/ft^3. This density is significantly greater than that of the in-place liner clay for the infiltrometer tests (see Table 5-2) while permeability of the liner is expected to be similar to l.0E-7 cm/sec when the biasing of the evaporation on the infiltrometer tests is considered. Given the climate at the site, this low permeability barrier will limit infiltration through the clay cap to immeasurably small levels. The clay infiltration/radon barrier will be extended to intersect the clay liner to form a complete encapsulation of the tailings. Appendix J contains a discussion of infiltration modeling that was performed for the site. This modeling indicates that only a tiny fraction of an inch of water is expected to penetrate the barrier annually, with an expected rate of infiltration of less than 0.06 gpm over the covered tailings area. The maximum present drainage rate observed is less than this rate. The present depression configuration, sandy material on the surface and additional drainage area contributing water indicates that the 0. 06 gpm prediction is extremely conservative and likely at least ten times too large.

5.4.8 Accumulation of Infiltrate Within Tailings

The presence of the liner beneath the tailings raises concerns for accumulation of infiltrate that penetrates the clay barrier within the tailings. This situation is sometimes referred to as the "bathtub" effect. With the decommissioning of the drainage system and installation of the clay cap, there will be no provision for collecting drainage from the tailings cell, and the cell will become a semi-sealed system. The clay cap will dramatically limit infiltration of water into and through the tailings but there will be minute quantities of water that do penetrate the cap. There are two factors that will prevent accumulation of significant quantities of water within the tailings. The first and most important factor is that the clay cap will only be subjected to a positive head during severe precipitation events and then only for brief periods. It will take a very severe precipitation event to produce a temporary "water table" on top of the clay cap, and this saturated zone will only persist briefly until lateral drainage, evaporation or evapotranspiration remove the water. Conversely, the water within the tailings will migrate through the permeable materials above the clay liner and will produce a small "pool" in the lowest portion of the cell. The thickness of this saturated zone is not expected to exceed a few inches. The size and thickness of this pool will be a function of the area of saturated flow necessary to convey the trivial quantities of infiltrate penetrating the cap. This pool area will be subject to saturated flow, while the infiltration through the cap will be under partially saturated conditions.

There is a very dramatic change in the hydraulic conductivity (permeability) when the flow becomes unsaturated. With unsaturated flow, only a portion of the pore space is used to transmit the water and capillary forces dominate the process. Many methods have been developed to predict hydraulic conductivity as a function of moisture content (e.g. Campbell, 1974) but these typically require obscure, unreliable or difficult to quantify soils properties. However a general observation of typical hydraulic conductivity vs. moisture content relationships reveals a 20-fold to 200-fold reduction in hydraulic conductivity when a soil with 46% porosity is at a 24% moisture content as opposed to saturated. This indicates that the "pool" of saturation on the clay liner need only occupy a small fraction of the area of the clay cap in order to drain the infiltrate.

The second factor that mitigates the potential for a "bathtub" effect is the required placement density of the clay in the cap. The measured density of the clay liner is generally 10 lb/ft^3 smaller than the minimum specified density of the clay cap. As density increases, the permeability decreases significantly and the permeability of the cap will likely be measurably smaller than that of the liner. This factor and that described in the preceding paragraphs combine to produce a situation where the capacity for transmission of water through the liner, although very small, is dramatically greater than potential infiltration through the clay cap.

5.5 Construction Considerations

The construction of the radon/infiltration barrier is the primary consideration in the cover construction. The specifications for moisture, density, and gradation of the clay barrier material are rigorous. Other cover and fill materials also require a measure of construction control to minimize potential settlement, control dust, and assure an adequate base for placement of subsequent layers.

During construction, the surface of the cover layers will be inspected periodically and following significant precipitation events or windstorms. Any damage to the interim/grading cover, clay radon/infiltration barrier, or rocky soil cover will be corrected prior to proceeding with construction in the areas of damage. Damage may include gullying, sediment deposition, displacement of cover materials by wind or other significant disturbance of the cover layers. The damaged areas will be repaired to meet or exceed the appropriate moisture and/or density specifications.

5.5.1 Tailings Cell Radon Barrier Placement

5.5.1.1 Responsibilities

Construction work under this specification will be performed by earthwork or rock placement contract or by Uranium One Americas' manpower.

Quality control testing/inspection will be done by Uranium One Americas and a contract soil testing service.

5.5.1.2 Performance Standards

1. All clay used for the radon barrier will be obtained in the designated borrow areas and subject to the approval of Uranium One Americas personnel or their representative.

2. The clay will be excavated and processed in a manner protective of the resource and

will not be wantonly wasted or adulterated.

3. The clay will be moisture conditioned to 24% to 30%. The clay may be moisture conditioned at the borrow or other designated location, but may not be moisture conditioned on the surface of the tailings. Adjustment of the moisture content of the clay on the tailings cover area to compensate for evaporation or delays in coverage of the clay layer will be allowed.

4. The clay radon barrier will be placed in maximum compacted lift thickness of six (6) inches and compacted to a minimum density of 90 lb/ft . The compaction may be by sheepsfoot, vibratory compactor, or other approved method. Clay that does not meet the density or moisture specifications must be reworked, retested and/or removed.

5. The clay radon barrier will be placed to 90% - 125% of the design thickness of 18 inches in no less than three lifts. The average thickness of the clay barrier on the covered tailings area will not be less than 100% of the design thickness of 18 inches. Exceedence of 125% of the design thickness will be tolerated if there is no detrimental effect on drainage systems or design grades. No clay or fill materials shall be placed under adverse weather conditions, including freezing temperatures, or during or immediately after heavy precipitation events. Uranium One Americas shall determine when these adverse conditions exist.

5.5.1.3 Testing and Inspection

1. Daily visual inspection of clay excavated and placed during construction shall be performed by Uranium One Americas or its designee. The visual inspection shall be performed to ensure clay is being placed in conformance to the specifications. All clay used for the radon barrier will be obtained in the designated borrow areas and subject to the approval of Uranium One Americas personnel or their representative.

2. A complete standard Proctor test (ASTM D-698) will be conducted by Uranium One Americas or its representative at a frequency of not less than once per 7500 yd^3 of clay barrier. A one-point Proctor test will be conducted by Uranium One Americas or its representative at a frequency of not less than once per 2500 yd^3 of clay barrier.

3. The gradation of the clay will be determined by Uranium One Americas or its representative using sieve analysis to the #200 screen at a frequency of not less than once per 1000 yd^3 of clay barrier. A minimum of one sieve analysis will also be conducted by Uranium One Americas or its representative for every day in which 150 yd^3 or more of clay barrier is placed. A minimum of 75% of the clay barrier material must pass the #200 screen.

4. The in-place density and moisture content of the clay will be determined by Uranium One Americas or its representative using at a frequency of not less than once per 500 yd^3 of clay barrier. A minimum of one in-place density/moisture content test will also be conducted for every day in which 150 yd^3or more of clay barrier is placed. The minimum acceptable density for the cover is 90 lb/ft^3, and the moisture content must be

within the range of 24% to 30%. Acceptable methods for determining the in-place moisture content include the oven drying method (ASTM D-2216), the microwave drying method (ASTM D-4643), the Speedy moisture meter (AASHTO T217) or the nuclear density gauge (ASTM D-3017). For all methods other than the oven drying method, a duplicate moisture determination will be made with the oven drying method at a frequency of once for every ten moisture content samples. These correlation tests will be used to calibrate the nuclear density gauge or to confirm accuracy of the other testing method to a maximum deviation of 1% in measured moisture content from the oven drying method. In the event of a failure in the correlation tests, the frequency of duplicate moisture determinations will be increased to once per five moisture samples until no failures occur for five successive correlation tests. For the nuclear density gauge, a series of 10 pre-construction correlation tests will be performed for samples in the immediate tailings cell area. If more than 30% of the correlation tests fail after a single calibration, the nuclear density gauge will not be acceptable.

5. The acceptable methods for in-place density determination include the sand cone method (ASTM D-1556), the nuclear density meter (ASTM D-2922), and a combination of the sand cone method and a driven tube density sampler. If the nuclear density meter is used, a correlation/calibration test with the sand cone method will be performed at a frequency of once per five density samples. In addition, a pre-construction series of 10 tests using both the sand cone method and the nuclear density meter will be performed. These tests will be performed on the surface of the tailings to confirm that gamma interference does not bias the nuclear density meter readings. If more than 30% of the tests fail (discrepancy of more than 2.5 lb/ft^3 between the two methods), the nuclear density meter will not be acceptable. If the combination method (driven tube density sampler) is used, a correlation sample will be performed with the sand cone method at a frequency of once per five density samples. If the driven tube density samples are not within an allowable deviation of 2.5 lb/ft^3 when compared with the sand cone method, the frequency of correlation tests will be increased to once per two samples until there are no failures in five successive correlation tests.

6. Clay radon/infiltration barrier that has not been covered within 48 hours of placement wil1 be tested for moisture content to insure the minimum moisture content of 24% is met. The testing will be at frequency of not less than one (1) sample per 10,000 square feet of affected area. The sampling will be to a depth of not more than three (3) inches. If the minimum moisture content of 24% is not met, sufficient water to adjust the moisture content to a minimum of 27% will be uniformly applied to the affected area of the in-place clay barrier. If precipitation on the clay barrier causes the delay in covering of the clay, construction on the cover will be delayed until the surface is dry enough to proceed without damage to the clay by equipment traffic.

7. The thickness of the clay barrier will be determined by survey or by coring. The total thickness will be verified at a frequency of no less than once per 20,000 ft^2 of clay barrier area. Uranium One Americas and/or its representative will determine the appropriate method for confirming clay barrier thickness.

8. Permeability testing of the barrier material will be performed at the direction of Uranium One Americas or its representative prior to or during construction. A minimum of five permeability tests will be performed at varying density to develop a correlation of density and permeability. This correlation will then be used to determine the required density to produce a permeability of l.OE-07cm/sec or less. The minimum density will be that which results in a permeability of l.OE-07 or less (based on the correlation), or 90 lb/ft^3 , whichever is greater.

5.5.1.4 Documentation and Reporting

1. Uranium One Americas shall maintain a daily construction activity log, recording the thicknesses, quantities and locations of clay placed and significant events or conditions that affect the placement and properties of the materials.

2. Contract soil testing service shall report all tests, in writing, on a weekly basis and shall report all failing tests immediately to Uranium One Americas.

5.5.1.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the Uranium One Americas' representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and any necessary corrective action.

2. The designated corrective action will be implemented before additional related work is permitted. Uranium One Americas will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by Uranium One Americas for any nonconformance that, in Uranium One Americas' judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

5.5.1.6 Records

1. A daily project journal will be maintained by Uranium One Americas' representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. Uranium One Americas will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.

5.5.2 Tailings Cell Interim/Grading Cover Placement

5.5.2.1 Responsibilities

Construction work under this specification will be performed by earthwork or rock placement contract or by Uranium One Americas' manpower.
Quality control testing/inspection will be done by Uranium One Americas using a contract soil testing service.

5.5.2.2 Performance Standards

1. All interim/grading cover will be obtained in the designated borrow areas and subject to the approval of Uranium One Americas' personnel or their representative. The interim/grading cover will be placed directly on top of the graded surface of the ore in the tailings cell.

2. The interim/grading cover will be moisture conditioned to a minimum of 10% by weight (dry basis) for sandy materials and a minimum of 15% by weight for materials with a significant fraction (20% or more by weight) passing the #200 sieve. The moisture conditioning is necessary to facilitate compaction and control dust.

3. The interim/grading cover will be placed in maximum compacted lift thickness of six (6) inches and compacted by sheepsfoot, vibratory compactor, or other approved method.

4. The interim/grading cover will be placed to a minimum of 90% of the design thickness of 12 inches in no less than two lifts. Excess thickness of the interim/grading cover may be placed at the direction of Uranium One Americas or its designee to achieve the desired surface for clay barrier placement. No interim/grading cover materials shall be placed under adverse weather conditions, including freezing temperatures, or during or immediately after heavy precipitation events. Uranium One Americas shall determine when these adverse conditions exist.

5.5.2.3 Testing and Inspection

1. Daily visual inspection of interim/grading cover excavated and placed during construction shall be performed by Uranium One Americas or its designee. The visual inspection shall be performed to ensure interim/grading cover is being placed in conformance to the specifications. All interim/grading cover will be obtained in the designated borrow areas and subject to the approval of Uranium One Americas personnel or their representative.

2. The interim/grading cover will be visually classified by Uranium One Americas' personnel or their representative. Sieve analysis, moisture content and in-place density testing may be performed by Uranium One Americas or its representative. No frequency of testing is designated because the specification for this material is very broad. Methods of testing will conform to those described in Section 5.5.1.3.

3. The thickness of the interim/grading cover will be determined by survey methods or by coring. The thickness will be verified at a frequency of no less than once per 20,000 ft^2 of interim cover area. Uranium One Americas and/or its representative will determine the appropriate method for confirming thickness.

5.5.2.4 Documentation and Reporting

1. Uranium One Americas shall maintain a daily construction activity log, recording the thicknesses, quantities and locations of interim/grading cover placed and significant events or conditions that affect the placement and properties of the

materials.

2. Contract soil testing service shall report all tests, in writing, on a weekly basis and shall report all failing tests immediately to Uranium One Americas.

5.5.2.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the Uranium One Americas representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and the necessary corrective action to be taken if required.

2. The designated corrective action will be implemented before additional related work is permitted. Uranium One Americas will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by Uranium One Americas for any nonconformance that, in Uranium One Americas' judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

5.5.2.6 Records

1. A daily project journal will be maintained by Uranium One Americas' representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. Uranium One Americas will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.

5.5.3 Tailings Cell Rock and Rocky Soil Cover Placement

5.5.3.1 Responsibilities

Construction work under this specification will be performed by earthwork or rock placement contract or by Uranium One Americas' manpower.

Quality control testing/inspection will be done by Uranium One Americas using a contract soil testing service.

5.5.3.2 Performance Standards

1. All rocky soil cover will be obtained in the designated borrow areas and subject to the approval of Uranium One Americas personnel or its representative. The rocky soil cover will be placed on top of the clay radon/infiltration barrier.

2. The rocky soil cover will be screened to remove stones greater than nine inches in diameter to facilitate placement in appropriate layer thickness.

3. Moisture conditioning of the rocky soil cover will be at the direction of Uranium One Americas or its representative to control dust and facilitate placement at appropriate

density.

4. The rocky soil cover will be placed in maximum compacted lift thickness of eight (8) inches. The rocky soil cover will be placed in a manner to avoid disturbance of the clay barrier, and construction traffic will be routed to achieve uniform compaction over the tailings surface.

5. The rocky soil cover will be placed to a minimum of 90% of the design thickness of 24 inches in no less than three lifts. Excess thickness of the rocky soil cover may be placed at the direction of Uranium One Americas or its designee to achieve the desired surface for rock mulch and riprap placement. No rocky soil materials shall be placed under adverse weather conditions, including freezing temperatures, or during or immediately after heavy precipitation events. Uranium One Americas shall determine when these adverse conditions exist.

5.5.3.3 Testing and Inspection

1. Daily visual inspection of rocky soil cover excavated and placed during construction shall be performed by Uranium One Americas or its designee. The visual inspection shall be performed to ensure rocky soil cover is being placed in conformance to the specifications. All rocky soil cover will be obtained in the designated borrow areas and subject to the approval of Uranium One Americas personnel or its representative.

2. The rocky soil cover will be visually classified by Uranium One Americas personnel or their representative. Sieve analysis, moisture content and in-place density testing may be performed by Uranium One Americas or its representative. No frequency of testing is designated because the specification for this material is very broad. Methods of testing will conform to those describe in Section 5.5.1.3.

3. The thickness of the rocky soil cover will be determined by survey methods or by coring. The thickness will be verified at a frequency of no less than once per 20,000 ft^2 of interim cover area. Uranium One Americas and/or its representative will determine the appropriate method for confining thickness.

5.5.3.4 Documentation and Reporting

1. Uranium One Americas shall maintain a daily construction act1v1ty log, recording the thicknesses, quantities and locations of rocky soil cover placed and significant events or conditions that affect the placement and properties of the materials.

2. Contract soil testing service shall report all tests, in writing, on a *weekly* basis and shall report all failing tests immediately to Uranium One Americas.

5.5.3.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the Uranium One Americas representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and the necessary corrective action to be taken if required.

2. The designated corrective action will be implemented before additional related work is permitted. Uranium One Americas will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by Uranium One Americas for any nonconformance that, in Uranium One Americas' judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

5.5.3.6 Records

1. A daily project journal will be maintained by Uranium One Americas' representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. Uranium One Americas will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.

5.5.4 Tailings Cell Ore Placement

5.5.4.1 Responsibilities

Construction work under this specification to be performed by earthwork or rock placement contract or by Uranium One Americas' manpower.

Quality control testing/inspection by Uranium One Americas and contract soil testing service.

5.5.4.2 Performance Standards

1. The ore material will be hauled from the stockpile area to the tailings area for disposal. Any ore that is spilled or otherwise distributed must be cleaned up and delivered to the tailings for disposal. All materials contaminated with the ore must also be placed in the tailings cell.

2. If there are visible blocks or cemented solids exceeding eight (8) inches within the ore placed in the tailings, additional ripping, disking or other mechanical crushing methods will be used to break the ore down to less than eight (8) inches in diameter. Breaking the material down with wheel rolling or tracked equipment will be acceptable. The ore material will be placed at as high a density as practical with uniform compaction by equipment traffic. Additional compaction effort may be required at the direction of Uranium One Americas or its representative.

3. Moisture conditioning of the ore will be at the direction of Uranium One Americas or its representative to control dust and facilitate placement at appropriate density. A minimum of 10% moisture content by weight is specified. Adjustments of the moisture content will be at the direction of Uranium One Americas or its representative.

4. The ore will be placed in maximum compacted lift thickness of eight (8) inches.

5. No ore shall be placed under adverse weather conditions, including freezing temperatures, or during or immediately after heavy precipitation events. Uranium One Americas shall determine when these adverse conditions exist.

5.5.4.3 Testing and Inspection

1. Daily visual inspection of ore excavated and placed during construction shall be performed by Uranium One Americas or its designee. The visual inspection shall be performed to ensure ore is being placed in conformance to the specifications. The removal of the ore from the stockpile area will be at the direction of Uranium One Americas or its representative.

2. The ore will be visually classified by Uranium One Americas personnel or their representative. Sieve analysis, moisture content and in-place density testing may be performed by Uranium One Americas or its representative. No frequency of testing is designated because there are no specifications for this material. Methods of testing will conform to those described in Section 5.5.1.3.

5.5.4.4 Documentation and Reporting

1. Uranium One Americas shall maintain a daily construction activity log, recording the thicknesses, quantities and locations of ore placed and significant events or conditions that affect the placement and properties of the materials.

2. The contract soil testing service shall report all tests, in writing, on a weekly basis and shall report all failing tests immediately to Uranium One Americas.

5.5.4.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the Uranium One Americas' representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and the necessary corrective action to be taken if required.

2. The designated corrective action will be implemented before additional related work is permitted. Uranium One Americas will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by Uranium One Americas for any nonconformance that, in Uranium One Americas' judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

5.5.4.6 Records

1. A daily project journal will be maintained by Uranium One Americas' representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent

reclamation and contract records.

2. Uranium One Americas will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.

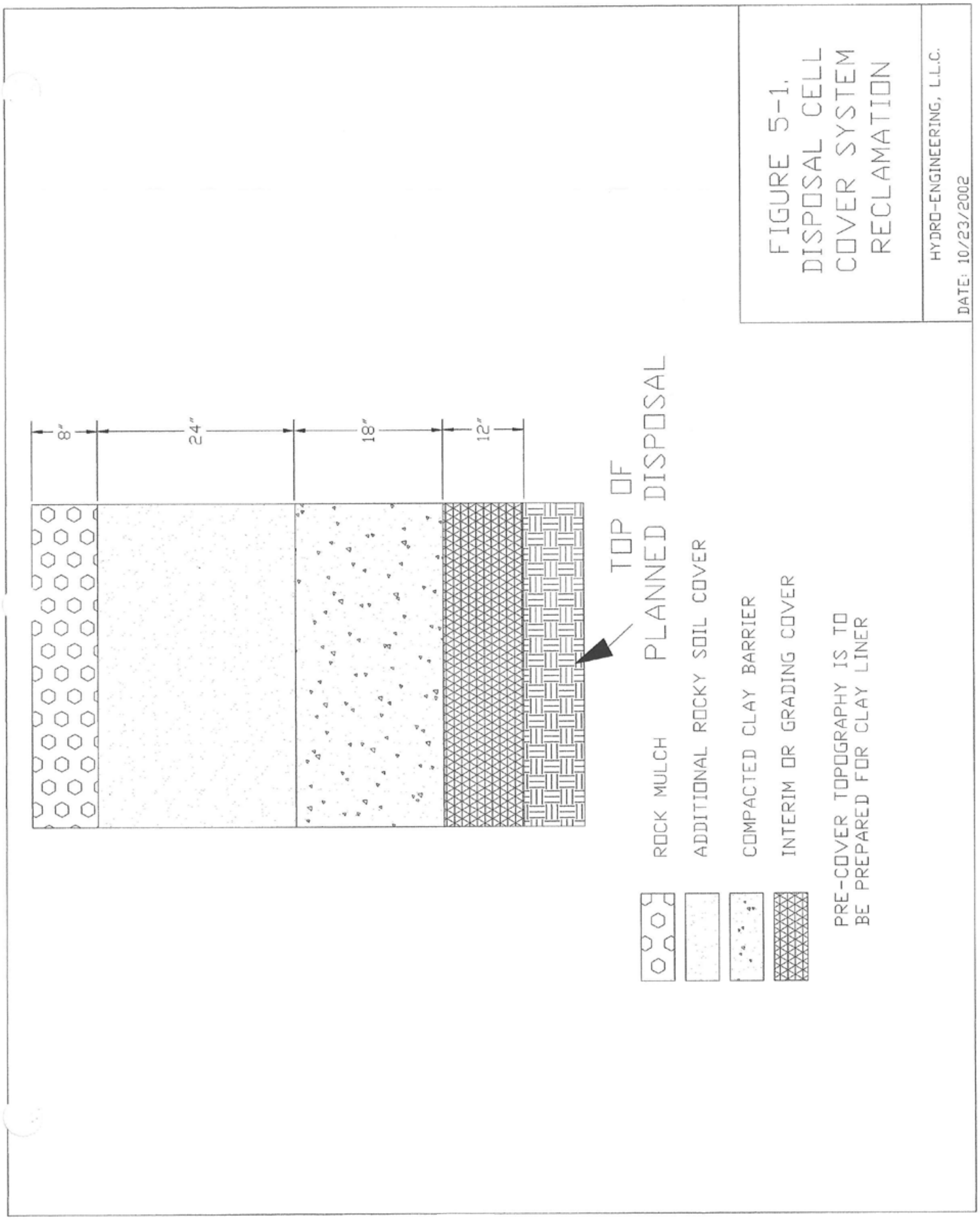


FIGURE 5-1.
DISPOSAL CELL
COVER SYSTEM
RECLAMATION
HYDRO-ENGINEERING, L.L.C.
DATE: 10/23/2002
8"
24"
18"
12"
TOP OF
PLANNED DISPOSAL
ROCK MULCH
ADDITIONAL ROCKY SOIL COVER
COMPACTED CLAY BARRIER
INTERIM OR GRADING COVER
PRE-COVER TOPOGRAPHY IS TO
BE PREPARED FOR CLAY LINER

6.0. EROSION PROTECTION OF THE TAILINGS IMPOUNDMENT

6.1 Tailings Dispersal By Erosion

Tailings and other contaminated material will be encapsulated above the existing cross valley berm. The cover system and drainage configuration has been designed to prevent erosion of the tailings cover. There will be no tailings or other contaminated material downstream of the cross valley berm, and thus the encapsulated tailings occupy only the northern portion of the original tailings facility. References to the tailings dam are made although the dam does not currently impound tailings and will not impound tailings after reclamation.

Erosion control measures will prevent the encroachment of gullies or significant erosion within the protected tailings area. A secondary concern for the drainage configuration is to provide positive drainage for the covered tailings area to prevent extended ponding over the tailings during precipitation events. The cross valley berm outslope will be reconfigured, channeling the runoff to the natural drainage between the cross valley berm and the present tailings dam. The tailings dam will be breached and the natural drainage reestablished (see Figures 6-1 and 6-2). The configuration of the dam breach and surrounding area allows for severe flood surge pond storage, which provides additional stability to the tailings area drainage. The majority of the tailings surface will be mildly sloping and protected against erosion with rock mulch. With the exception of the reconfigured cross valley berm outslope, the runoff from the covered tailings area is collected in a channel which flows to the north and off the protected area. The channel then bends to the east and south and discharges to the south into the Shootaring Canyon drainage above the present location of the tailings dam. Drainage from the plateau west of the tailings cells will flow onto the tailings surface. With the exception of this area to the west, the runoff from the area surrounding (including the mill area) wi11 be captured in the channel and discharged to the south with the runoff from the covered tailings area. The flow over the covered tailings area will be almost entirely sheet flow at mild slopes.

6.2 Below-Grade Disposal

Uranium One Americas tailings impoundment is in a natural depression enclosed on all sides by a cap. Such a tailings area minimizes the dispersion of tailings by wind and water erosion. The tailings disposal basin is effectively surrounded by natural cliffs and hills. It is anticipated, because of this fact, that net deposition of windblown soils is expected to occur over the impoundment area, rather than Joss of coverings over the tailings due to wind erosion. Accordingly, natural deposition will be exploited to enhance the security of the projected tailings impoundment.

6.3 Drainage Design

The drainage system will be designed to convey the Probable Maximum Flood (PMF) with no damage to the tailings encapsulation system. The PMF is a combination of the Probable Maximum Precipitation (PMP) event and worst-case runoff conditions. The estimated PMP as taken from Hydrometeorological Report No. 49 (NWS, 1977) is 8.25 inches in 1 hour. This storm is derived for a 1 square mile area at an elevation up to 5000 feet above mean sea level. The short duration storm is most applicable for the small drainage at the Shootaring site, and the local high intensity storm over a small area represents the most severe runoff producing storm event for this situation. The riprap and rock mulch protection will be of sufficient size and gradation to withstand the erosive forces, thereby protecting the integrity of the impoundment cap and drainage system.

The PMP storm distribution has a pronounced impact on the magnitude and duration of peak flows. In order to produce runoff estimates representing the most severe plausible precipitation event, the PMP storm was distributed according to two methods. The first method uses a bell shaped rainfall distribution with the peak intensity at the midpoint of the storm (see Figure 6-3). This storm distribution was used in the HEC-1 modeling of the runoff from the entire mill and tailings area drainage basin. The storm distribution presented in Figure 6-4 was used in the modeling of overland flow which is discussed in the following paragraphs.

The drainage basin characteristics are presented in Table 6-1. The time of concentration was calculated with Kirpich's method (see Barfield et al., 1983). In calculating the time of concentration, the flow paths were segmented into sections of relatively uniform slope and then the time of concentration for the sub-basin was the sum of the time of concentration for each segment. The PMP distribution in Figure 6-3 produces a very severe runoff condition for basins of the size, shape and slope for the tailings area because the maximum precipitation intensity occurs when the entire basin is contributing runoff to critical locations. HEC-1 was used to evaluate the peak runoff flows for the drainage basin with the SCS curve number method. The curve number was set at 88 for the general drainage area representing poor range conditions with a reasonably well drained soil under antecedent moisture condition III (nearly saturated prior to the storm). This represents a very severe combination of conditions that produces large quantities of runoff. Much of the surface soil in the drainage basin is within the Entrada sandstone or derived from the sandstone and is well-drained and has a relatively high infiltration rate. The curve number for the Tails and North Tails sub-basins was set at 80 to reflect the presence of highly permeable rock mulch layer over a large percentage of the individual sub- basin area.

TABLE 6-1. BASIN CHARACTERISTICS FOR THE MILL AND TAILINGS AREA

BASIN	Area (acre)	Area (mi^2)	Hydrologic High Elev. (ft-msl)	Hydrologic Low Elev. (ft-msl)	Basin Relief (ft)	Basin Length (ft)	Basin Slope (ft/ft)	Kirpich's tc (hour)	Kirpich's tL (hour)	Total Kirpich's tL (hour)	SCS Curve Number
NORTH	52.4	0.082	4640	4480	160	2910	0.055	0.185	0.1109	0.1364	88
(Sect. 2)			4480	4436	44	530	0.083	0.042	0.0255		
NORTH MILL	41.3	0.065	4640	4520	120	1640	0.073	0.106	0.0639	0.1431	88
(Sect. 2)			4520	4470	50	1015	0.049	0.086	0.0514		
(Sect. 3)			4470	4435	35	530	0.066	0.046	0.0278		
SOUTH MILL	30.1	0.047	4560	4548	12	590	0.020	0.079	0.0476	0.0919	88
(Sect. 2)			4548	4468	80	450	0.178	0.028	0.0168		
(Sect. 3)			4468	4434	34	520	0.065	0.046	0.0275		
NORTH TAILS	3.4	0.005	4850	4800	50	235	0.213	0.016	0.0095	0.0590	80
(Sect. 2)			4800	4451	349	490	0.712	0.017	0.0105		
(Sect. 3)			4451	4436	15	535	0.028	0.065	0.0390		
TAILS	14.1	0.022	4860	4800	60	185	0.324	0.011	0.0067	0.0953	80
(Sect. 2)			4800	4454	346	390	0.887	0.013	0.0081		
(Sect. 3)			4454	4437	17	1045	0.016	0.134	0.0805		
SOUTH	81.0	0.127	4830	4800	30	165	0.182	0.013	0.0077	0.1289	88
(Sect. 2)			4800	4430	370	345	1.072	0.011	0.0068		
(Sect. 3)			4430	4382	48	960	0.050	0.082	0.0490		
(Sect. 4)			4382	4364	18	890	0.020	0.109	0.0654		

Level-pool flood routing was used in the HEC-1 modeling to reflect surge pond storage in the flat area upstream of the confluence of basins Tails through North Mill. A large rock ledge structure is used to restrict peak flows under severe to catastrophic flows without permanently impounding water. Large stones will be placed in the channel to conform to the design channel configuration. This will create a highly porous "dam" that temporarily restricts extreme event flows. These stones that form the ledge will have a minimum D_{50} of 24 inches and thus there will be ample voids between the rocks to convey moderate storm runoff. The downstream edge of the ledge will be placed at a relatively mild slope to transition to the downstream discharge channel. Figure 6-5 presents the surge pond area and storage and rock ledge discharge characteristic.

The surface of the covered tailings area will be covered by a rock mulch cover to protect the radon barrier and the tailings from wind dispersal and water erosion. This layer will be engineered to meet or exceed the required size, gradation and thickness requirements for the PMF. At the location of intersection or joint where the radon barrier meets the native ground, the transition rock will extend onto the native ground for protection. The PMP distribution in Figure 6-4 was used in the estimation of peak runoff flows for the overland flow paths on the tailings surface shown in Figure 6-2. The distribution was developed using a proportioning technique presented in Hydrometeorological Report No. 55A (NWS, 1988) wherein the largest 15-minute precipitation depth is placed at the beginning of the one-hour storm. Each successive 15-minute precipitation depth is reduced and a polynomial fit was applied to the discrete proportions to give a continuous distribution curve. This distribution places the peak intensity at the beginning of the storm with a declining intensity as the storm continues. With the relatively short time of concentration for the overland flow paths, this type of distribution produces much larger peak flows. The overland flow paths were segmented into sections of relatively uniform slope using the sequential lettering in the suffix of the path name. The time of concentration was summed while moving downstream on each overland flow path. Table 6-2 presents the hydraulic characteristics of overland flow. The discharge was calculated on a unit width basis using the Rational Formula expressed as:

$$Q=CIA$$

Where:
- Q = discharge per unit width in cfs/ft.
- C = Runoff coefficient
- I = Rainfall Intensity in inch/hr.
- A = Area in acres

TABLE 6-2. OVERLAND FLOW PATH CHARACTERISTICS AND ROCK MULCH DESIGN.

Path Name	Length (feet)	Relief (feet)	Slope (ft/ft)	Progressive Time of Concentration (min)	Discharge (cfs/ft)	Flow Depth (Inch)	Manning's n	Abt/ Johnson Rock D50 (Inch)	Target Rock D50 (Inch)
01-1A	175	60	0.34	0.63	0.118	0.29	0.015	--- Off Tailings	-----
01-18	330	326	0.99	1.04	0.342	0.40	0.015	-- Off Tailings	---
01-1C	75	20	0.27	1.20	0.392	0.64	0.015	--- Off Tailings	-----
01-1D-UPSTREAM*		0.02	0.02		0.981*	3.25	0,024	0.96	2.00
01-1D	550	11	0.02	2.57	0.680	2.56	0.024	0.78	2.00
01-2A	170	50	0.29	0.65	0.115	0.30	0.015	-- Off Tailings	-----
01-28	370	328	0.89	1.14	0.365	0.43	0.015	— Off Tailings	-----
01-2C	120	22	0.18	140	0.447	0.78	0.015	— Off Tailings	-----
01-2D-UPSTREAM*	1	0.0215	0.02		1.116.	3.49	0.025	1.07	2.00
01-20	325	7	0.02	2.22	0.593	2.31	0.024	0.75	2.00
01-2E	75	5	0.07	2.40	0.638	2.01	0.031	1.27	2.00
03-1A	60	12	0.20	0.34	0.036	0.26	0.031	0.41	2.00
03-18	50	4	0.08	0.61	0.066	0.44	0.026	0.39	2.00
01-4A	90	18	0.20	046	0.054	0.34	0.032	0.51	2.00
01-5A	280	56	0.2	1.11	0.168	0.70	0.035	0.97	2.00

• In the transition from the native surface to the rock mulch, a concentrating factor of 2.5 is used for the upstream discharge to insure that the rock on the upstream boundary is adequate to accommodate concentrated flow. The segments with the suffice -UPSTREAM are short sections to allow rock sizing with this concentrated flow.

The runoff coefficient was set at 0.9 for off-tailings areas with no rock mulch and at 0.8 for the rock mulch areas. The rainfall intensity was calculated from the polynomial equation used to develop Figure 6-4 with the time of concentration. A minimum time of concentration of 2.5 minutes was used (recommended in NUREG/CR-4620) and this gave a maximum computational intensity of 32.75 inches/hour. The discharge for each successive segment was calculated using a cumulative area and the progressive time of concentration.

In Table 6-2, there are two additional overland flow path segments in paths 01-1 and 01-2. These segments are labeled 01-1D-UPSTREAM and 01-2D-UPSTREAM and are located at the transition from the native surface to the rock mulch. These segments were inserted to allow rock sizing with a concentrated flow that may develop in the area upstream of the rock-protected area. The unit width discharge upstream of these segments was multiplied by a factor of 2.5 to produce a concentrated flow discharge, which was used in subsequent rock sizing calculations.

6.4 Rock Cover Protection Calculations

The rock protection provided for the covered tailings area is divided into the two categories of channel rock and rock mulch. This distinction is made on the basis of the methods for calculating rock size. Channel rock size is sized according to estimates of peak flow from the HEC-1 modeling using Manning's equation. The rock mulch is sized according to the unit discharge estimates in Table 6-2.

6.4.1 Rock Quality

Three sources of rock are within a practical distance of the site and all three sources appear to be of common origin with very similar properties. These three sources include: the quarry (samples designated with the prefix QU) south of the mill area, the rock on the tailings dam face (samples designated with the prefix DS), and the rocky soil cover (samples designated with the prefix RSC) which was used as a protective cover for the tailings cell clay liner and exists over the area northeast of the north dike. Of these three rock sources, only the quarry rock and the dam rock will be used for rock mulch and channel rock. The quarry will be used to produce intermediate sized rock for rock mulch, large rock for channels, and the finer fraction from rock processing may be used in the upper cover layer for the tailings. The rock from the dam face will be used primarily for the large channel rock, although a suitable rock mulch product may also be generated from the processing.

All three rock sources consist of two types of rock in very similar proportions. Approximately 36% of each rock source is made up of rock identified as an andesite porphyry, while the remainder is sandstone. Seven rock samples were taken with three from the quarry area, two from the dam and two from the rocky soil cover. The average percentages of porphyry in the samples were 35%, 36.5% and 36% for the quarry, dam and rocky soil cover samples, respectively. All samples were taken from rock that ranged in size from one inch to approximately six inches. Durability testing on these samples has revealed that the porphyry is of relatively good quality while the quality of the sandstone is marginal. It is likely that the proportion of porphyry or other more durable stones in larger rocks (diameter of one foot or greater) will be significantly larger than the average 36% for smaller rock and this was confirmed with rock counting estimates of rock proportions. However, the composite quality for rock of all sizes was assumed to be represented by the samples from the rock mulch sized rock. A sample of the porphyry and a sample of the sandstone were also subjected to petrographic analysis, which revealed that there was no smectite or other expansive clays in the rock. The results of the durability testing and petrographic analysis are included in Appendix C. The results of an earlier durability test (done in 1997) are also included in Appendix C. The durability results for this earlier sample were reasonably consistent with those for recent samples, but the proportions of rock type for this earlier sample are estimates.

The rock quality results and scoring for the rock samples are presented in Table 6-3. A composite rock quality score for the quarry rock and the dam rock was calculated using the individual NRC rock scoring method for the porphyry and the sandstone, and then using the proportions of each rock type to composite the score. The results reveal composite scores of 63.3 and 51.8 for the quarry and dam rock respectively. The RSC rock will not be used in the rock mulch or channel rock. With rock quality scores less than 80, the rock requires oversizing of 16.7% for the quarry rock and 28.2% for the dam rock. In order to overcome concerns for the rock quality, a minimum oversizing of 50% was established for all rock mulch and channel rock. This oversizing will result in a corresponding minimum overthickening of at least 50%. It should be noted that the marginal score for the dam rock was due largely to the marginal quality of the sandstone. The dam rock will be used primarily for channel riprap with a diameter ranging from approximately 6 inches to approximately 36 inches. As mentioned in a preceding paragraph, there is a strong likelihood that this bigger rock on the dam has a significantly higher percentage of the more durable rock, which would result in a much better composite score. However it is not possible to perform the quality testing on riprap of this size, anonly a preliminary assessment of rock proportions is possible until some rock retrieval and processing is underway. A rock counting technique was used to assess proportions of rock types and this procedure and the results are discussed in Appendix C. Hence, the established minimum oversizing and overthickening of 50% will likely be even more conservative than indicated by the oversizing for present quality concerns.

TABLE 6-3. ROCK QUALITY AND SCORING

Quarry Rock Quality Results:

Quarry Andesite Porphyry:

Lab Test	Result	NRC Score	Weight	NRC Score * Weight	Max. Score
Sp. Gr.	2.532	5.64	9	50.8	90
Absorp, %	1.6	3.8	2	7.6	20
Sod. Sulf., %	1.91	9.545	11	105.0	110
L.A. Abr., %	3.7	8.65	1	8.7	10
			Totals	172.0	230
			Percentage Score:		74.8%

Quarry Sandstone:

Lab Test	Result	NRC Score	Weight	NRC Score * Weight	Max. Score
Sp. Gr.	2.445	3.9	6	23.4	60
Absorp, %	2.13	2.74	5	13.7	50
Sod. Sulf., %	4.33	8.335	3	25.0	30
L.A. Abr., %	5.1	7.94118	8	63.5	80
			Totals	125.6	220
			Percentage Score:		57.1%

Quarry Composite:

Percent Andesite Porphyry	35%
Percent Sandstone	65%
Composite Score =(.748*.35)+(.571*.65) =	**63.3%**

Shootaring Dam Rock Quality Results:

Dam Andesite Porphyry:

Lab Test	Result	NRC Score	Weight	NRC Score * Weight	Max. Score
Sp. Gr.	2.529	5.58	9	50.2	90
Absorp, %	1.63	3.74	2	7.5	20
Sod. Sulf., %	4.16	8.42	11	92.6	110
L.A. Abr., %	3.9	8.55	1	8.6	10
			Totals	158.9	230
			Percentage Score:		69.1%

Dam Sandstone:

Lab Test	Result	NRC Score	Weight	NRC Score * Weight	Max. Score
Sp. Gr.	2.392	2.84	6	17.0	60
Absorp, %	2.25	2.5	5	12.5	50
Sod. Sulf., %	12.86	3.856	3	11.6	30
L.A. Abr., %	7.7	6.375	8	51.0	80
			Totals	92.1	220
			Percentage Score:		41.9%

Dam Composite:

Percent Andesite Porphyry	36.5%
Percent Sandstone	63.5%
Composite Score =(.691*.365)+(.419*.635) =	**51.8%**

Rock Soil Cover Quality Results:

Rock Soil Cover Andesite Porphyry:

Lab Test	Result	NRC Score	Weight	NRC Score * Weight	Max. Score
Sp. Gr.	2.475	4.5	9	40.5	90
Absorp, %	2.16	2.68	2	5.4	20
Sod. Sulf., %	8.46	5.90588	11	65.0	110
L.A. Abr., %	5.5	7.70588	1	7.7	10
			Totals	118.5	230
			Percentage Score:		51.5%

Rock Soil Cover Sandstone:

Lab Test	Result	NRC Score	Weight	NRC Score * Weight	Max. Score
Sp. Gr.	2.356	2.12	6	12.7	60
Absorp, %	3.1	0.8	5	4.0	50
Sod. Sulf., %	13.48	3.608	3	10.8	30
L.A. Abr., %	9.9	5.05882	8	40.5	80
			Totals	68.0	220
			Percentage Score:		30.9%

The rock scores do not meet the minimum score of 65 for frequently saturated areas. However, the environment at the Shootaring site is arid with an estimated annual precipitation of 7 inches. Snowfall is very infrequent and the entire tailings facility is located on a massive sandstone formation. Hence, the designation of channels and rock toes as "frequently saturated" is not applicable to this site. With the drainage provided by the sandstone, rock filter and rock, the potential for saturation of the rock is limited to that occurring during and immediately after catastrophic events.

6.4.2 Channel Rock Sizing

The HEC-1 modeling described in a previous section was used to determine peak flows, which were then used in sizing of the rock for channels. The HEC-1 input file is included in Appendix D, along with the flow schematic and hydrographs for selected sections. Figure 6-6 presents hydrologic channel sections where the channel configuration and rock sizing were established. The flow characteristics and rock sizing are presented in Table 6-4. Manning's equation was used to determine hydraulic flow characteristics with a uniform Manning's n of 0.035 for rock sections. The Abt/Johnson method presented in NUREG-1623 was used to size the channel rock because it is applicable over a wide range of slope conditions. The rock and design methodology meets the criteria in NUREG-1623 for using the Abt/Johnson method with the exception of the specific gravity. The composite specific gravity of the composite rock is approximately 2.5 as opposed to the recommended minimum of 2.65. However, this is a deficiency of only 6% while the rock is being oversized by a minimum of 50%. As discussed earlier, the rock is substantially oversized and overthickened to alleviate any concerns on suitability of the rock.

TABLE 6-4. CHANNEL CONVEYANCE AND ROCK SIZING.

Hydrologic Cross-Section	Base Width (ft)	Right Side Slope (?H: 1V)	Left Side S lope (?H :1V)	Bottom Slope (ft/ft)	Discharge (cfs)	Normal Flow Depth (ft)	Flow Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Flow Velocity (fps)
HC -1	20	5	5	0.0140	303	1.740	4 9.9	37.74	1.32	6.07
HC-2	20	5	4	0.0050	373	2.585	81.8	43.84	1.87	4.56
HC-3	30	5	4	0.0300	2386	3.639	168.8	63.56	2.66	14 .14
HC-4	50	4	4	0.0700	2386	2.285	135.1	68.84	1.96	17.66

Hydrologic Cross-Section	Top Width (ft)	Froude Number	Average Unit Discharge (cfs/ft)	Abt/Johnson Rock D50 (ft)	Rock Type+	Target Riprap D50 (ft)
HC-1	37.40	0.93	10.56	0.26	INT	0.50
HC-2	43.27	0.58	11.79	0.18	INT	0.50
HC -3	62.75	1.52	51.45	0.88	LRG	1.67
HC-4	68.28	2. 21	40.35	1.10	LRG	1.67

\+ - Rock Type INT = Intermediate Rock
LRG = Large Rock

The channel rock is divided into three sizes to fit various channel rock hydraulic characteristics. The primary channel rock has a minimum D_{50} of 20 inches (1.67 feet). This rock is used in sections HC-3 and HC-4 as shown on Figure 6-6 and presented in Table 6-4. Based on the required rock size in Table 6-4, this large riprap is oversized by a minimum of 52%. The rock will be placed to a thickness of two times the design D_{50}. The second rock size will be riprap with a minimum D_{50} of 6 inches (0.5 feet). This rock will be used in the upstream section of the primary channel (sections HC-1 and HC-2 in Figure 6-6). The minimum oversizing provided by the rock in these sections of channel is 92% and this same rock will be used for a rock apron on the downstream edges of the rock mulch areas where applicable.

6.4.3 Overland Flow Rock Sizing

The overland flow rock sizing is presented in Table 6-2 along with the flow characteristics for the flow paths. Like the channel rock sizing, the rock mulch sizing was done with the Abt/Johnson method. The maximum required rock D_{50} according to Table 6-2 is 1.27 inches while the minimum design D_{50} is 2 inches, which provides a minimum of 57% oversizing. The rock mulch will be placed to a thickness of 8 inches or more to provide a substantial measure of conservatism for the top slope. With this substantial overthickening, the D_{50} of the rock mulch can approach 6 inches without compromising the placement. The rock will be screened to limit the D_{100} to approximately 9 inches. As shown in Figure 6-6, a rock apron will be placed at the downstream edge of rock mulch areas where the discharge is to the native surface. This rock will have a minimum D_{50} of 6 inches and will be placed at a thickness of 12 inches.

6.4.4 Channel Rock Apron

A rock apron will be placed at the terminus of the major discharge channel just downstream of the cross valley berm. In addition to the stilling basin formed by the extension of the channel rock across the swale, very large stones will be placed in an apron across the swale as shown in Figure 6-6. These stones will be selected with a diameter of 24 inches or greater and will be placed in a toe protection to a thickness of 48 inches or more. Figure 6-7 presents a cross-section schematic to illustrate the placement of the rock apron.

6.4.5 Porous Rock Ledge

Figure 6-8 presents a schematic of the porous rock ledge discussed in Section 6.3. The ledge serves to restrict peak flows during a PMF level event. It also provides a secondary rock protection to prevent encroachment into the covered tailings area. The location of the porous rock ledge prevents migration of erosional features east of the tailings through the channel and into the tailings.

6.4.6 Rock Filters

A rock filter will be used under the channel rock to prevent erosion of the underlying materials through the rock. The filter system for the large (1.67 foot D_{50}) rock will consist of 8 inches of

The rock mulch underlain by 8 inches of the quarry area material, which is unsorted with the exception of removal of the +9-inch fraction. The filter for the intem1ediate (0.5 foot D_{50}**)** rock and will consist of 8 inches of the quarry area material which is unsorted with the exception of removal of the +9 inch fraction. No specific filter system will be placed under the rock mulch or the portions of the channel rock over the covered tailings area because the upper two feet of the cover consists of the quarry area material from which the +9 inch fraction has been removed. The presence of this rocky material on the covered tailings area negates the need for an additional filter.

6.4.7 Sediment Impacts

The drainage design or the covered tailings area is not subject to detrimental effects from sediment deposition. With the exception of the sandstone bluff west of the tailings cell, there is no unprotected upstream contributing area to deliver sediment onto the tailings area. The drainage channel configuration allows accumulation of substantial depths of sediment with no plausible potential for diversion or blockage of the channel. Using the position of the rock ledge as an example, a sediment depth of approximately 14 feet would be required to effectively divert tailings area runoff over the reclaimed cross valley berm. Downstream of the porous rock ledge location the channel slope is 7% and there is virtually no potential for sediment accumulation. The distance between the rock ledge location and the point at which the 7% slope begins is approximately 380 feet and the elevation difference with the 14 feet deep sediment blockage would be approximately 17 feet. This leads to the observation that the sediment forming the blockage would have to be able to resist erosion on a 4.5% slope in order to cause the diversion and this is extremely unlikely. It is possible that a few inches or feet of sediment will accumulate in the mildly sloping sections of the channel east of the tails, but eventually the sediment will reach a depth where a psuedo-steady grade is achieved. These depths will be far below those that will have detrimental effects on the channel. At some point, a severe runoff event will likely flush the channel. The mildly sloping sections of the channel east of the tailings are too deeply incised for sediment accumulation to have any impact.

Sediment accumulation on the rock mulch covered tailings surface will not adversely affect the overland drainage pattern. With t he relatively small covered tailings area and the simple drainage pattern at moderate slopes, the potential sediment caused diversions on the rock mulch surface area are limited to very local flow concentrations occurring over a distance of a few feet. The rock mulch is sufficiently oversized and overthickened to withstand local flow concentrations under PMF conditions, despite the fact that PMF flows will almost certainly flush local sediment blockages.

6.5 Dam Breach

The current Shootaring Canyon darn will be breached to provide materials for the tailings cover construction and to prevent accumulation of excessive quantities of water behind the dam. The dam will be breached to a depth of approximately 4374 ft. above MSL which leaves a small depression upstream of the dam with an estimated bottom elevation of 4364 ft. above MSL.

This depression will act as a surge pond during extreme events. Due to the permeability of the sandstone on which the facility was constructed, it is unlikely that significant long-term ponding of runoff will occur in this depression. However, this small depression will likely prevent significant runoff through the dam breach for all but very severe events. This small depression will trap sediment from larger runoff events. Some of the rock currently on the downstream face of the dam will be placed to form an outfall from the breach on the downstream side of the reclaimed dam. The tailings dam and the downstream rock outfall are located nearly 1000 feet from the rock toe of the channel from the covered tailings area and thus the dam breach is not an integral part of the tailings erosion protection. However this breach configuration should provide a stable downstream channel section and allow return of this off-tailings area to other beneficial use.

6.6 Landslide Impacts

The predominant feature along the west side of the tailings facility is a rock bluff. This rock bluff is composed of the native sandstone bedrock which underlies the tailings facility. The nearly vertical cliff areas on this bluff are between one hundred (100) and two hundred (200) feet high. The base or toe of the nearly vertical cliff is set back from the edge of the reclaimed tailings contact area a minimum of one hundred and fifty (150) feet and in most areas over two hundred (200) feet. At the base or toe of the sandstone cliff areas the ground slopes to the tailings cell area at roughly a 2:1 H/V slope. Scattered on the surface of the side slopes are an assortment of small and large blocks of weathered sandstone from past landslide and rock fall events. In the event of a landslide in which sandstone rocks and boulders come off the top or sides of the cliffs, this material would first impact on the sandstone slopes at or near the base of the cliff above the tailings cap. The side slopes and not the tailings cap would first absorb the kinetic energy of the falling material. The weathered sandstone rocks or boulders would have a tendency to fracture into smaller sizes. The fractured and weathered sandstone rocks would then slide or tumble into the previously fallen sandstone material further reducing the kinetic energy. Fragments of the boulders may continue to slide or tumble down the side slope towards the reclaimed tailings cell but it is unlikely that they will be large enough or retain enough energy to damage the cover system. The drainage in this area is to the east and north and there are no channels which could be blocked or diverted by the talus from the slopes.

6.7 Erosion Protection – Rock Materials and Placement

6.7.1 Responsibilities

Construction work under this specification will be performed under an earthwork or rock placement contract or by Uranium One Americas' manpower.

Quality control testing/inspection will be done by Uranium One Americas using a vendor soil testing service.

6.7.2 Performance Standards

1. All rock used for erosion protection shall be obtained in the designated borrow areas adjacent to the site as shown on Figure 6-9.

2. The rock shall be processed to produce those sizes and gradations as calculated in the erosion protection section of the specifications.

3. The quality of rock shall be not less than a weighted score of 50 for all applications of erosion protection. The rock has been oversized by a factor of 50% or more in the design process.

4. The rock used for covers on the tailings cell and riprap used in the channels shall be sized to provide a <u>minimum</u> D_{50} as follows:

Rock mulch for tailings surface	D_{50} = 2 inches
Intermediate channel riprap	D_{50} = 6 inches
Large channel riprap	D_{50} = 20 inches
Porous rock ledge riprap	D_{50} = 24 inches
Rock toe riprap	D_{50} = 24 inches

5. Rock covers and riprap shall be 90% - 125% of the following thickness:

Rock mulch for tailings surface	0.67 feet
Intermediate channel riprap	1.0 feet
Large channel riprap	3.3 feet
Rock toe riprap	4.0 feet

6. Filter and bedding materials and riprap shall be 90% - 125% of the following thickness:

Intermediate channel riprap filter outside of tailings	0.67 feet
Large channel riprap upper filter	0.67 feet
Large channel riprap lower filter	0.67 feet

7. Rock covers and riprap shall be placed by dumping and spreading with heavy equipment to:
a) maintain the acceptable gradation ranges listed above and avoid segregation of sizes
b) create a uniform cover surface free of visible high or low spots or ridges that could result in flow diversion. The surface irregularities for the large channel rock should not exceed 10% of the rock thickness over distances of several feet. The surface irregularities for the rock mulch and small channel rock are controlled by the thickness tolerance which limits irregularities to a few inches.

8. The excavation and/or shaping of the rock cut, transition protection and toe protection will be to the required dimensions as calculated in the erosion protection section of the specifications. The bedding material and coarse riprap will be placed to the design thicknesses and heights.

6.7.3 Testing and Inspection

1. Daily visual inspection of rock delivered and placed during construction shall be performed by Uranium One Americas or its designee. The visual inspection shall be performed to ensure rock is being placed in conformance to the specifications.

2. Prior to placement of rock, the top of the soil cover layer shall be surveyed for as-built information and to serve as baseline or bottom of the rock cover layer. Once the rock cover layer has been placed, it shall be resurveyed and compared against the top of soil cover layer for thickness verification of the placed rock material. This method does not negate or substitute for rock thickness testing procedures being performed by the use of a tape measure as the cover advances. As a guideline, this procedure should be performed on a regular basis to ensure that placement is to the specified thickness.

3. Testing procedures and frequencies of the rock cover materials shall be as follows:

   a. During production and placement of the riprap and bedding materials Uranium One Americas or its designee will define the locations and materials to be tested in the field. Gradation tests for each material type shall be performed a minimum of four times during production. During the preliminary stages of production a sample shall be obtained and tested. This will be followed by additional samples when approximately one- third and two-thirds of the total volume has been produced. A final sample shall be obtained and tested near the completion of production. Should the total quantity of materials to be produced be less than 30,000 cubic yards, samples shall be taken near production startup, near the one-third points of production and near completion of production for each type. If the total volume of material is greater than 30,000 cubic yards, a gradation test shall be performed for each additional 10,000 cubic yards or fraction thereof. The following gradation tests shall be performed during production of the rock cover materials:

TEST METHOD	TEST
ASTM C 117, ASTM C 136	Gradation
ASTMD 5519	Particle Size Analysis of Natural and Man-made Riprap Materials

   b. The durability of the rock cover material produced shall be evaluated based on criteria established in the NRC/STP *"Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites, Appendix D (August, 1990)*. The composite "rating" or "score" resulting from this evaluation must exceed 50 for acceptance of the rock material. Durability tests for each material type shall be taken at the same frequency intervals as gradation testing, once during the initial phase of production, near the one-third and two-thirds points of production and near the completion of production. Should the total quantity of materials to be produced be less than 30,000 cubic yards, samples shall be taken near production startup, near the one-third points of production and near completion of production for each type. If the total volume of material is greater than 30,000 cubic yards, a gradation test shall be performed for each additional 10,000 cubic yards or fraction thereof. Testing procedures shall be as follows:

TEST METHOD	TEST
ASTMC 127	Specific Gravity (Saturated surface dry basis)
ASTMC 127	Absorption
ASTMC 88 (5 cycles)	Soundness
ASTM C 131 (100 revolutions)	Abrasion

Petrographic examination of the rock has been performed and will not be repeated.

In the event that unforeseen rock types are encountered during production, a complete set of durability tests will be run and the material re-scored.

c. The suitability of the rock on the dam face to be processed for large channel rock will be evaluated in the field by a professional geologist or by personnel who have been trained by the Geologist in inspection/selection procedures. Rocks that have joints or planes of weakness at a spacing less than the established D50, or have excessive porosity, or have significant variation in grain size, or have undesirable shape and dimensions, or have other characteristics that render the rock inferior will be clearly marked and excluded from the rock to be placed in the tailings area channel. Striking of the rocks with a rock hammer or testing with a Schmidt hammer may be used to evaluate rock hardness at the direction of the Geologist or Engineer. The inspection/selection process will be done on all rock to be placed as large channel riprap in the tailings area channel.

d. The riprap placed in the channel will be visually inspected to insure that no significant quantities of inferior rock are placed within the channel. The rock will be removed and replaced in areas where the rock is deficient in size, shape or durability.

e. The surface of the large channel riprap will be surveyed and visually inspected to confirm the thickness of riprap and to insure that there are no local surface irregularities that could result in a flow diversion or constitute a significant deviation from design grades. Thickness of the riprap must be within 90% to 125% of design thickness. In addition, differences in thickness measured over a representative area (15 square feet or greater) cannot exceed 10% of the rock thickness over distances of up to 15 feet. The survey data will include channel centerline locations at a 100 foot interval supplemented by a minimum of three other survey points across the channel within each 100 foot interval. The thickness of rock riprap and filter may also be verified by excavation and direct measurement at selected locations.

f. The surface of the rock mulch will be surveyed and visually inspected to confirm the thickness of riprap and to insure that there are no local surface irregularities that could result in diversion of flows. The survey data will include a minimum of one survey point per 10,000 square feet of surface area. . The thickness of rock mulch may also be verified by excavation and direct measurement at selected locations.

6. 7.4 Documentation and Reporting

1. Uranium One Americas shall maintain a daily construction activity log, recording the thicknesses, quantities and locations of rock and bedding placed and significant events or conditions that affect the placement and properties of the materials.

2. Contract soil testing service shall report all tests, in writing, on a weekly basis and shall report all failing tests immediately to Uranium One Americas.

6.7.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified 'or verified by the Uranium One Americas representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and the necessary corrective action to be taken if required.

2. The designated corrective action will be implemented before additional related work is permitted. Uranium One Americas will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by Uranium One Americas for any nonconformance that, in Uranium One Americas' judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

6.7.6 Records

1. A daily project journal will be maintained by Uranium One Americas' representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. Uranium One Americas will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.

6.8 Excavation and Shaping of Channel Cut and Transition Protection

6.8.1 Responsibilities

Construction work under this specification will be performed under an earthwork or rock placement contract or by Uranium One Americas' forces.

Quality control testing/inspection will be done by Uranium One Americas using a vendor soil testing service.

6.8.2 Performance Standards

1. The channel cut, transition protection, and toe protection will be constructed to the lines, grades and dimensions as determined. The control points needed for the establishment of the construction staking of the work will be provided by Uranium One Americas or their representative. Actual construction staking may be performed by Uranium One Americas by their own forces if they elect or by a qualified firm for contract construction.

2. The material obtained from the channel cut excavation may be utilized as interim cover prior to placing the radon barrier. Excess material from the channel cut may be disposed of in approved locations.

3. All embankments outside of the tailings shall be placed in a maximum of eight (8) inch lifts and compacted by wheel rolling of equipment or other methods as directed by Uranium One Americas. Placement of embankment and fill materials within the tailings area is described in section 5.

4. No fill materials shall be placed under adverse weather conditions, including freezing temperatures, or during or immediately after heavy precipitation events. Uranium One Americas shall determine when these adverse conditions exist.

5. Excavation of the channel cut will not be performed by means of blasting without the written permission of Uranium One Americas. It must be demonstrated that any blasting performed will not jeopardize the stability of or the performance of the cross valley berm. All liabilities for the damage by blasting will be born by the contractor performing the excavation work.

6. All survey books used in the staking and checking of the ditches will be turned over to Uranium One Americas for review as requested and at termination of the project given to Uranium One Americas for their permanent records.

6.8.3 Testing and Inspection

1. Daily visual inspection of the construction activity shall be performed by Uranium One Americas. Verification of lines, grades and dimensions will be performed by use of survey equipment appropriate for verification needs.

6.8.4 Documentation and Reporting

1. Uranium One Americas shall maintain a daily construction activity log, recording the quantities and locations of ditch excavation and embankment and significant events or conditions that affect the placement and properties of the materials.

2. Vendor soil testing service shall report all tests, in writing, on a weekly basis and shall report all failing tests immediately to Uranium One Americas.

6.8.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the Uranium One Americas representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and the necessary corrective action to be taken if required.

2. The designated corrective action will be implemented before additional related work is permitted. Uranium One Americas will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

3. Stop-work orders may be issued by Uranium One Americas for any nonconformance that, in Uranium One Americas' judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

6.8.6 Records

1. A daily project journal will be maintained by Uranium One Americas' representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. Uranium One Americas will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.

6.9 Regrading and Shaping of Disturbed Borrow Areas

6.9.1 Responsibilities

Construction work under this specification will be performed by earthwork or rock placement contract or by Uranium One Americas' forces.

Quality control testing/inspection will be done by Uranium One Americas using a vendor soil testing service.

6.9.2 Performance Standards

1. All borrow areas shall be graded after all other construction activities have been completed and before revegetation activities of the affected area begins.

2. All slopes in the borrow areas will be regraded to a maximum slope of 4:1 horizontal to vertical after all materials required from such borrow area is obtained. The oversize, reject or excess processed material will be placed or scattered along any working face prior to the flattening of the slopes. The entire disturbed site will be regraded to maintain the directions and gradients of ground surfaces that existed prior to the borrow areas development, if practical.

3. After grading is complete, topsoil removed (if any) will be replaced in preparation of seeding.

4. Site seeding will follow topsoil placement (if any) and conform to the latest technologies for establishment of plant growths in arid regions. Seed certification slips as to type, species, and germination will be given to and retained by Uranium One Americas for permanent record requirements.

5. No seeding will be allowed while the ground is frozen or during times of freezing temperatures.

6.9.3 Testing and Inspection

1. Daily visual inspection of the regrading and seeding activities shall be performed by Uranium One Americas.

6.9.4 Documentation and Reporting

1. Uranium One Americas shall maintain a daily construction activity log, recording the regrading, topsoil placement, and seeding activities. An aerial photography survey will be performed of the entire site after completion of the final grading of all disturbed areas, tailings, and mill site. The resulting topographic map will be submitted as documentation of the adequacy of final lines and grades.

6.9.5 Nonconformances, Corrective Actions and Stop-Work Orders

1. Nonconformances will be identified or verified by the Uranium One Americas representative who will direct the contractor or field personnel to stop work or take specific corrective action. The appropriate technical consultant will be contacted as needed to identify the importance of the nonconformance and the necessary corrective action to be taken if required.

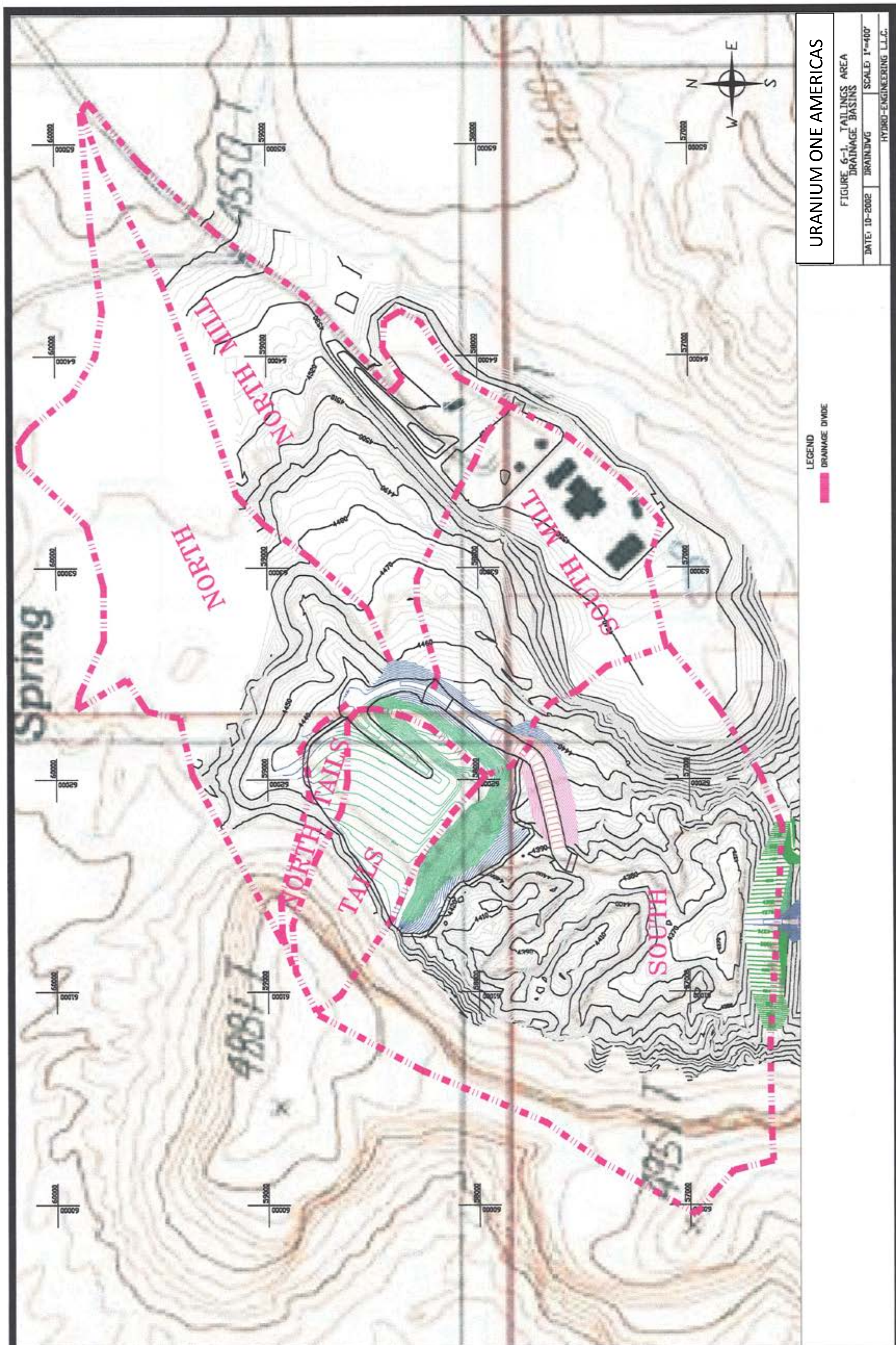
2. The designated corrective action will be implemented before additional related work is permitted. Uranium One Americas will verify the corrective action by appropriate measurements, tests, or other permanent documentation.

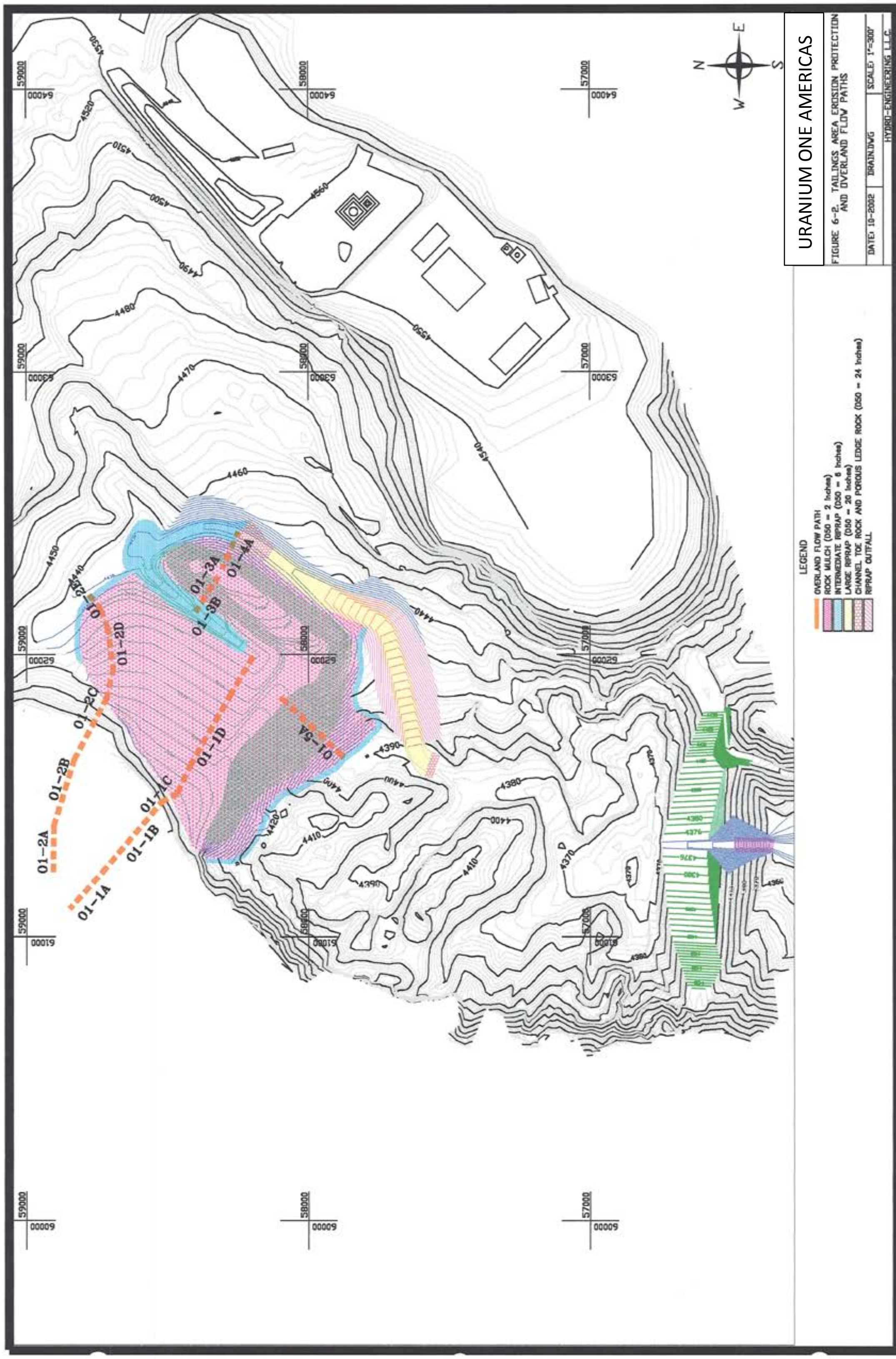
3. Stop work orders may be issued by Uranium One Americas for any nonconformance that, in Uranium One Americas' judgment, may jeopardize subsequent work that depends for its quality on the nonconforming work.

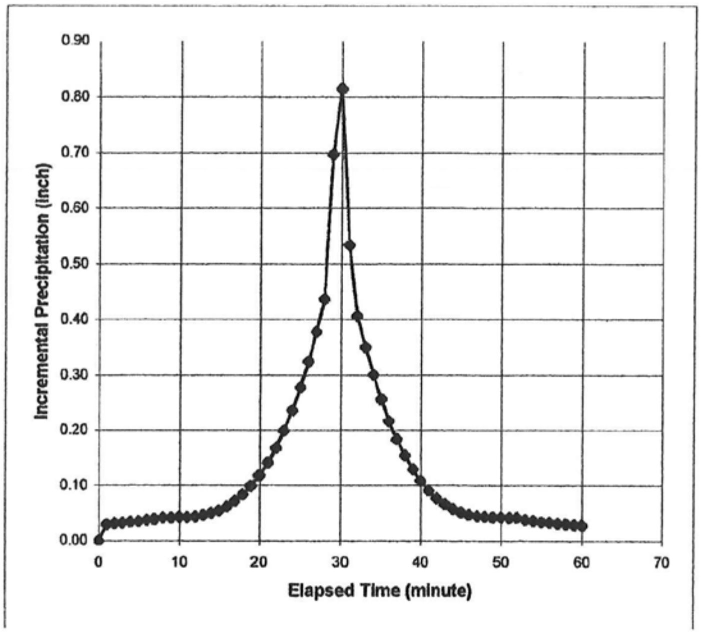
6.9.6 Records

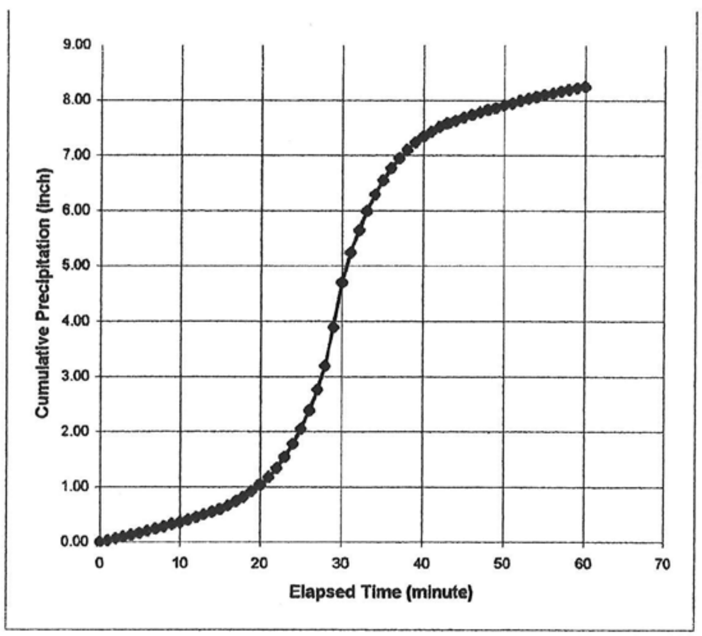
1. A daily project journal will be maintained by Uranium One Americas' representative. It will document the work accomplished, contract quantities for measurement and payment, nonconformances, corrective actions, stop-work orders, and conditions affecting the work. The daily journals will become a part of the permanent reclamation and contract records.

2. Uranium One Americas will maintain a permanent file of all testing, measurements, and other records of the work performed under this specification.


URANIUM ONE AMERICAS
FIGURE 6-1, TAILINGS AREA DRAINAGE BASINS
DATE: 10-2002
DRAIN.DWG
SCALE: 1"=400'
HYDRO-ENGINEERING L.L.C.
LEGEND
DRAINAGE DIVIDE
NORTH
NORTH MILL
SOUTH MILL
NORTH TAILS
TAILS
SOUTH
Spring
N
S
E
W
6-18

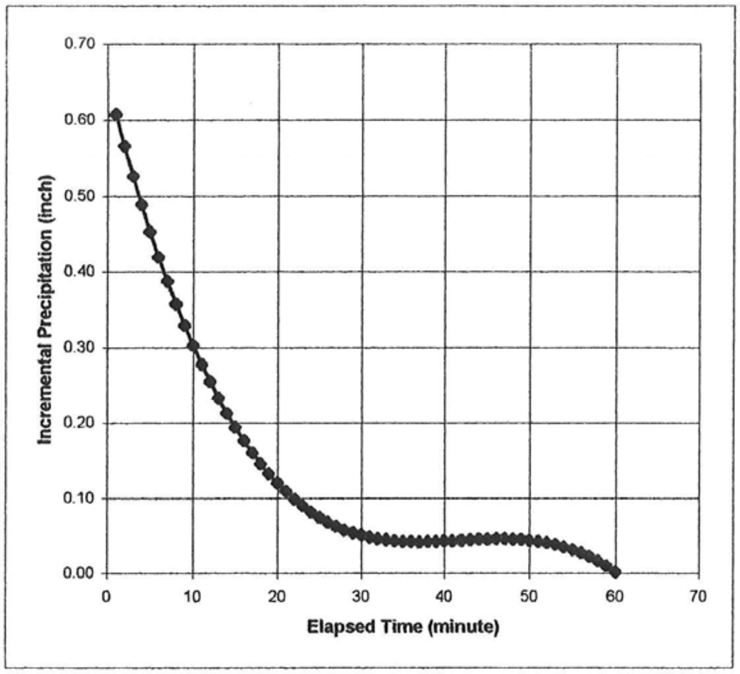

URANIUM ONE AMERICAS
FIGURE 6-2. TAILINGS AREA EROSION PROTECTION AND OVERLAND FLOW PATHS
DATE: 10-2002
DRAIN.DWG
SCALE: 1"=300'
HYDRO-ENGINEERING L.L.C.
6-19
LEGEND
OVERLAND FLOW PATH
ROCK MULCH (D50 = 2 Inches)
INTERMEDIATE RIPRAP (D50 = 6 Inches)
LARGE RIPRAP (D50 = 20 Inches)
CHANNEL TOE ROCK AND POROUS LEDGE ROCK (D50 = 24 Inches)
RIPRAP OUTFALL
N
S
E
W
01-1A
01-1B
01-1C
01-1D
01-2A
01-2B
01-2C
01-2D
01-3A
01-3B
01-4A
01-5A

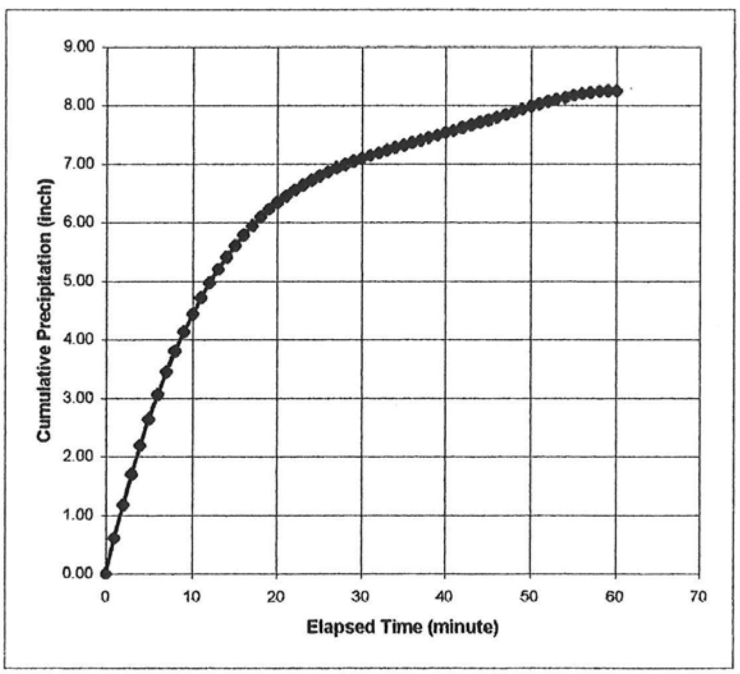




Time (minute)	Incremental Precipitation (inch)	Cumulative Precipitation (inch)
0	0.0000	0.0000
1	0.0293	0.0293
2	0.0308	0.0601
3	0.0323	0.0924
4	0.0337	0.1261
5	0.0352	0.1613
6	0.0367	0.1980
7	0.0382	0.2362
8	0.0417	0.2779
9	0.0418	0.3197
10	0.0420	0.3617
11	0.0424	0.4041
12	0.0435	0.4476
13	0.0457	0.4933
14	0.0493	0.5426
15	0.0544	0.5970
16	0.0618	0.6588
17	0.0715	0.7303
18	0.0840	0.8143
19	0.0996	0.9139
20	0.1186	1.0325
21	0.1414	1.1739
22	0.1683	1.3422
23	0.1998	1.5420
24	0.2361	1.7781
25	0.2775	2.0556
26	0.3244	2.3800
27	0.3774	2.7574
28	0.4363	3.1937
29	0.6968	3.8905
30	0.8145	4.7050
31	0.5338	5.2388
32	0.4061	5.6449
33	0.3501	5.9950
34	0.3003	6.2953
35	0.2561	6.5514
36	0.2173	6.7687
37	0.1835	6.9522
38	0.1543	7.1065
39	0.1295	7.2360
40	0.1086	7.3446
41	0.0914	7.4360
42	0.0774	7.5134
43	0.0663	7.5797
44	0.0579	7.6376
45	0.0516	7.6892
46	0.0472	7.7364
47	0.0445	7.7809
48	0.0429	7.8238
49	0.0421	7.8659
50	0.0419	7.9078
51	0.0418	7.9496
52	0.0415	7.9911
53	0.0374	8.0285
54	0.0360	8.0645
55	0.0344	8.0989
56	0.0330	8.1319
57	0.0316	8.1635
58	0.0300	8.1935
59	0.0286	8.2221
60	0.0279	8.2500

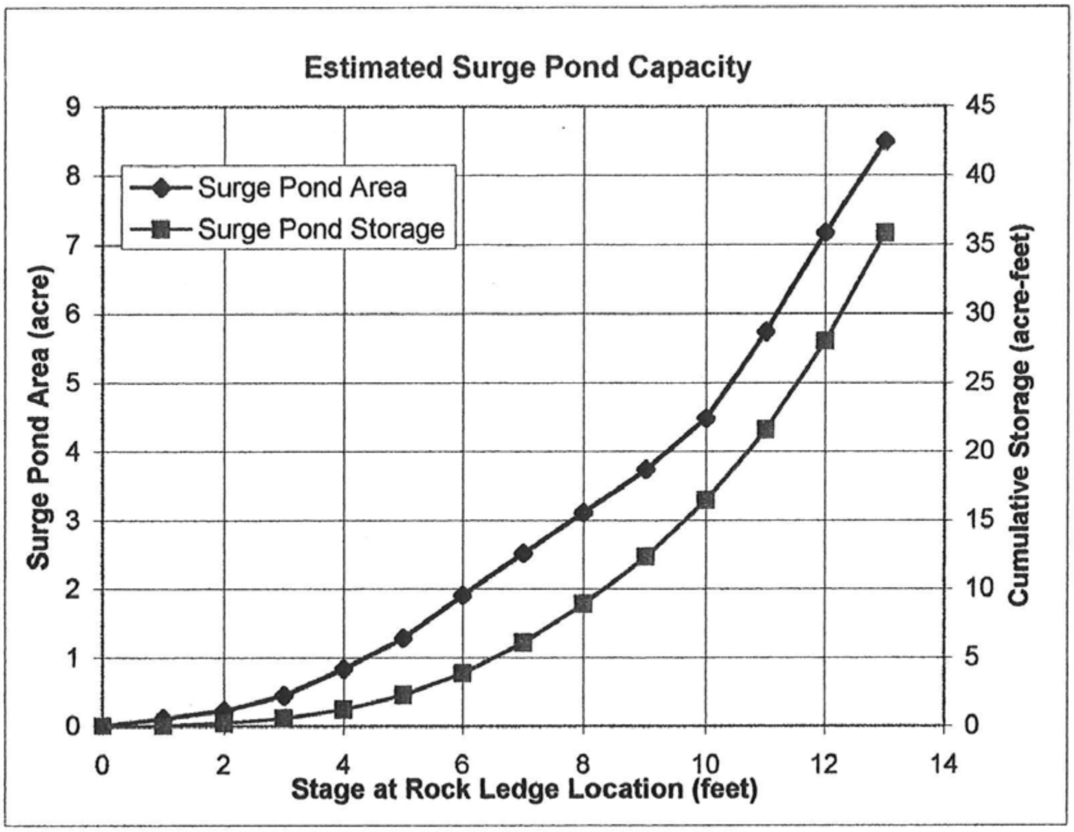
FIGURE 6-3. INCREMENTAL AND CUMULATIVE 1-HOUR, 1-SQUARE MILE PMP PRECIPITATION DISTRIBUTIONS FOR HEC-1 ANALYSIS





Time (minute)	Incremental Precipitation (inch)	Cumulative Precipitation (inch)
0	0.0000	0.0000
1	0.6073	0.6073
2	0.5657	1.1730
3	0.5261	1.6991
4	0.4886	2.1877
5	0.4530	2.6407
6	0.4193	3.0600
7	0.3876	3.4476
8	0.3576	3.8051
9	0.3294	4.1345
10	0.3028	4.4373
11	0.2780	4.7153
12	0.2547	4.9700
13	0.2330	5.2031
14	0.2128	5.4159
15	0.1941	5.6100
16	0.1767	5.7867
17	0.1607	5.9474
18	0.1460	6.0934
19	0.1325	6.2258
20	0.1202	6.3460
21	0.1090	6.4550
22	0.0989	6.5540
23	0.0899	6.6438
24	0.0818	6.7256
25	0.0746	6.8003
26	0.0684	6.8687
27	0.0629	6.9316
28	0.0582	6.9898
29	0.0543	7.0440
30	0.0509	7.0950
31	0.0483	7.1432
32	0.0461	7.1894
33	0.0445	7.2339
34	0.0433	7.2772
35	0.0426	7.3198
36	0.0422	7.3619
37	0.0420	7.4040
38	0.0422	7.4462
39	0.0425	7.4887
40	0.0430	7.5317
41	0.0436	7.5752
42	0.0442	7.6194
43	0.0448	7.6641
44	0.0453	7.7094
45	0.0457	7.7551
46	0.0459	7.8010
47	0.0460	7.8470
48	0.0457	7.8927
49	0.0451	7.9378
50	0.0442	7.9820
51	0.0428	8.0248
52	0.0409	8.0657
53	0.0385	8.1042
54	0.0355	8.1397
55	0.0319	8.1715
56	0.0276	8.1991
57	0.0225	8.2216
58	0.0166	8.2382
59	0.0099	8.2481
60	0.0023	8.2504

FIGURE 6-4. INCREMENTAL AND CUMULATIVE 1-HOUR, 1-SQUARE MILE PMP PRECIPITATION DISTRIBUTIONS FOR OVERLAND FLOW ANALYSIS



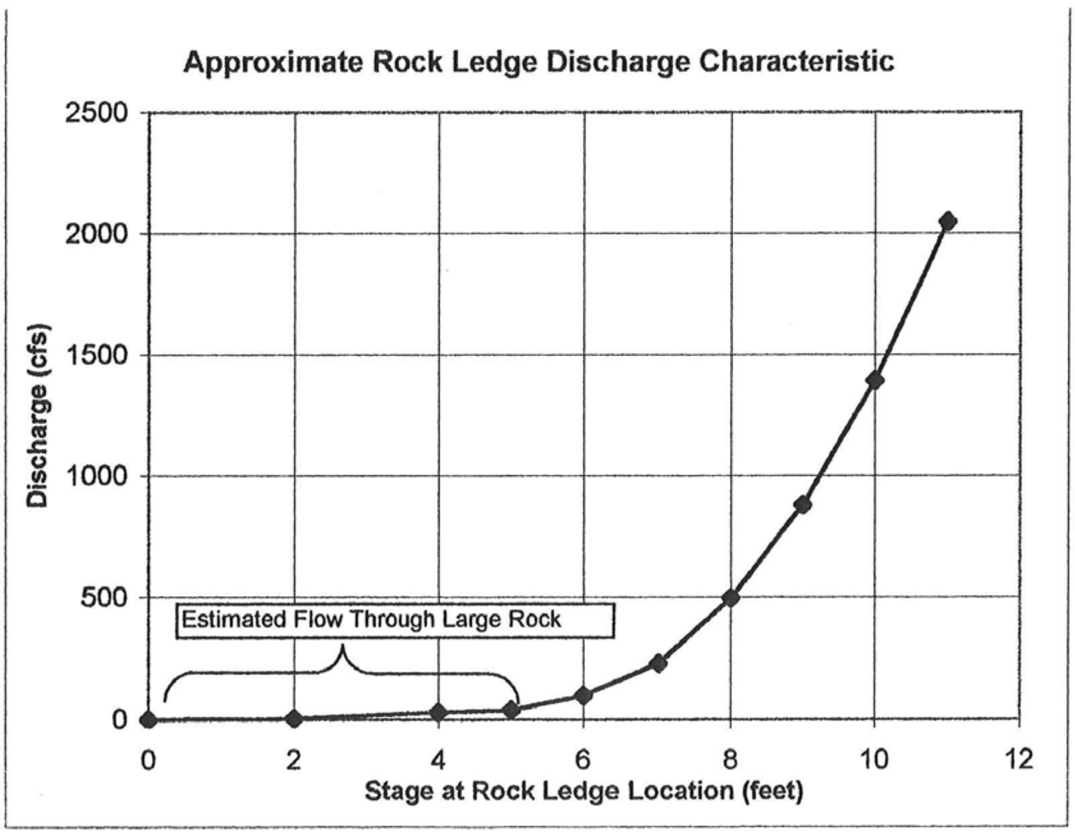
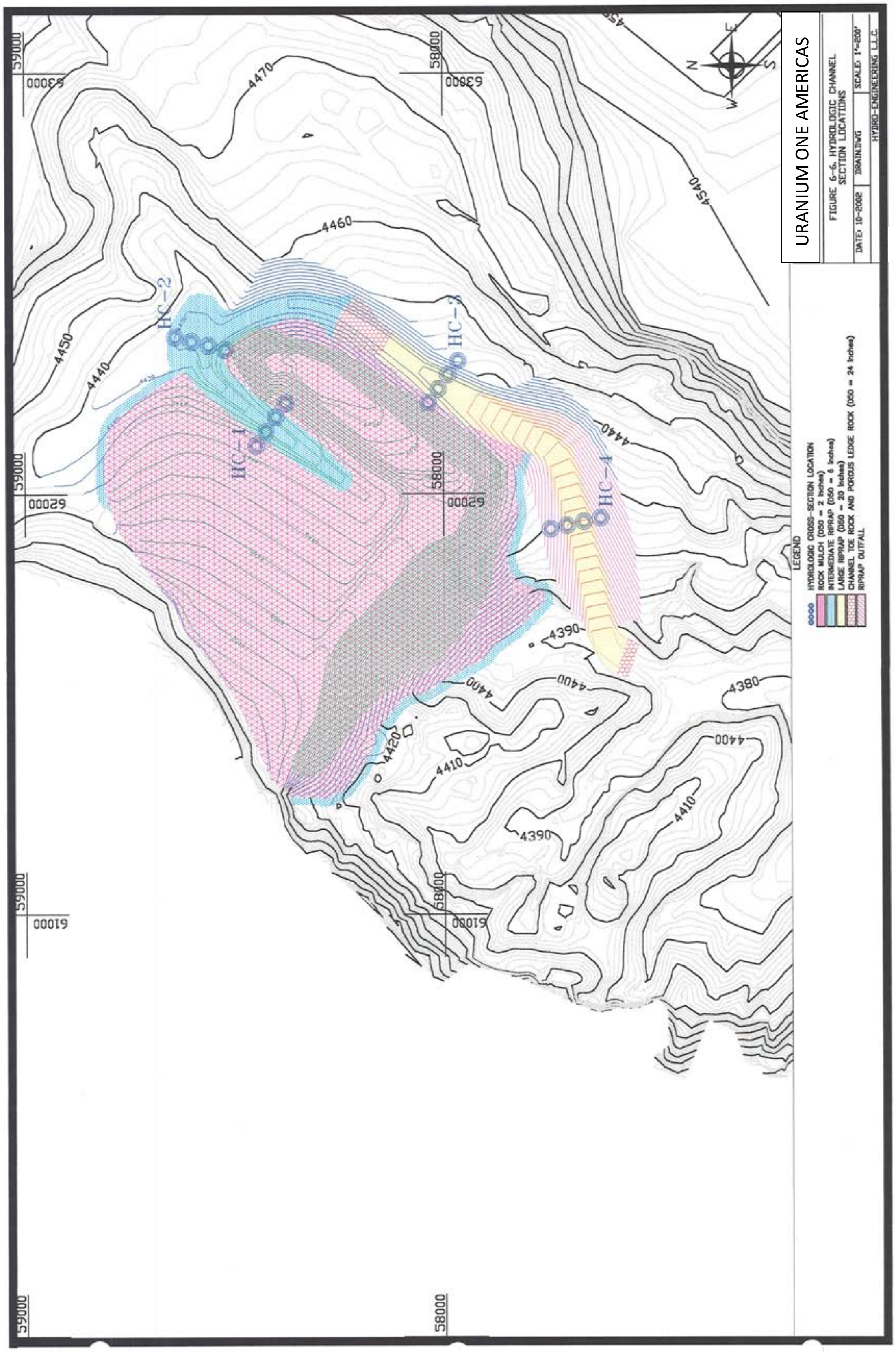


Figure 6-5. Surge Pond Storage and Porous Rock Ledge Discharge Characteristic


URANIUM ONE AMERICAS
FIGURE 6-6. HYDROLOGIC CHANNEL SECTION LOCATIONS
DATE: 10-2002
DRAIN.DWG
SCALE: 1"=200'
HYDRO-ENGINEERING L.L.C.
LEGEND
HYDROLOGIC CROSS-SECTION LOCATION
ROCK MULCH (D50 = 2 inches)
INTERMEDIATE RIPRAP (D50 = 6 inches)
LARGE RIPRAP (D50 = 20 inches)
CHANNEL TOE ROCK AND POROUS LEDGE ROCK (D50 = 24 inches)
RIPRAP OUTFALL
HC-1
HC-2
HC-3
HC-4
4470
4460
4450
4440
4540
4420
4410
4400
4390
4380
59000
58000
63000
62000
61000

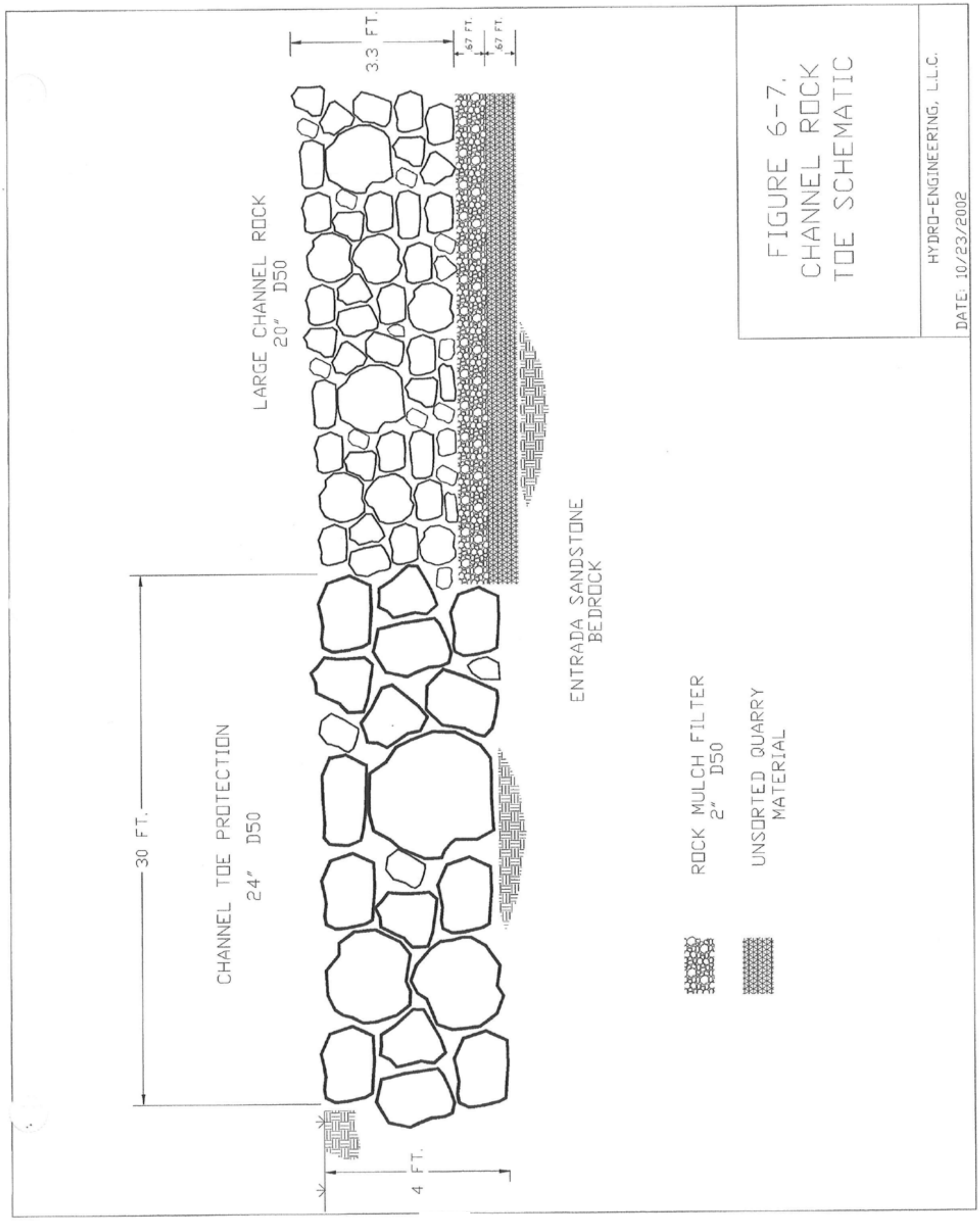


FIGURE 6-7.
CHANNEL ROCK
TOE SCHEMATIC

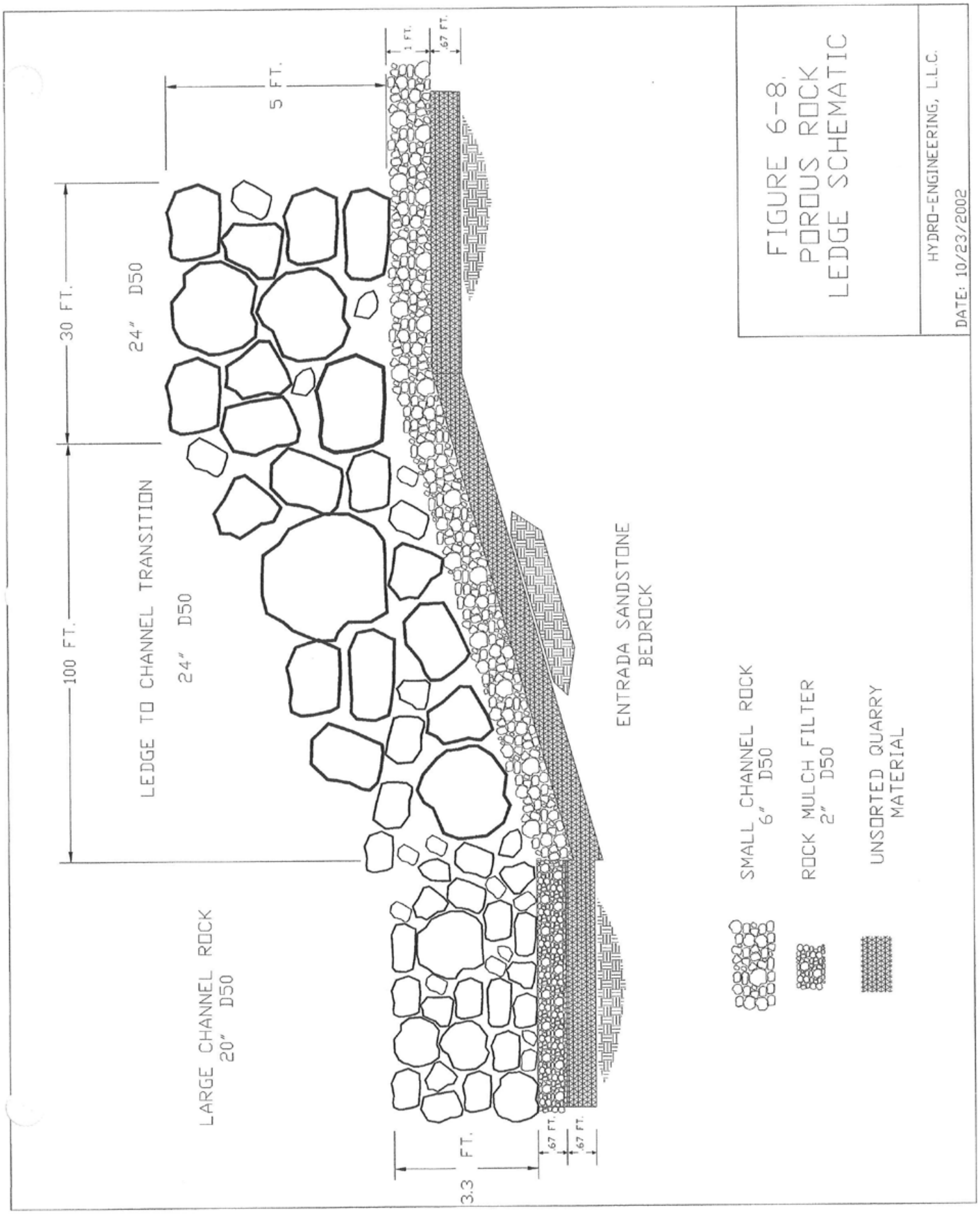


FIGURE 6-8.
POROUS ROCK
LEDGE SCHEMATIC
HYDRO-ENGINEERING, L.L.C.
DATE: 10/23/2002
5 FT.
1 FT.
.67 FT.
30 FT.
24" D50
LEDGE TO CHANNEL TRANSITION
100 FT.
24" D50
LARGE CHANNEL ROCK
20" D50
3.3 FT.
.67 FT.
.67 FT.
ENTRADA SANDSTONE
BEDROCK
SMALL CHANNEL ROCK
6" D50
ROCK MULCH FILTER
2" D50
UNSORTED QUARRY
MATERIAL

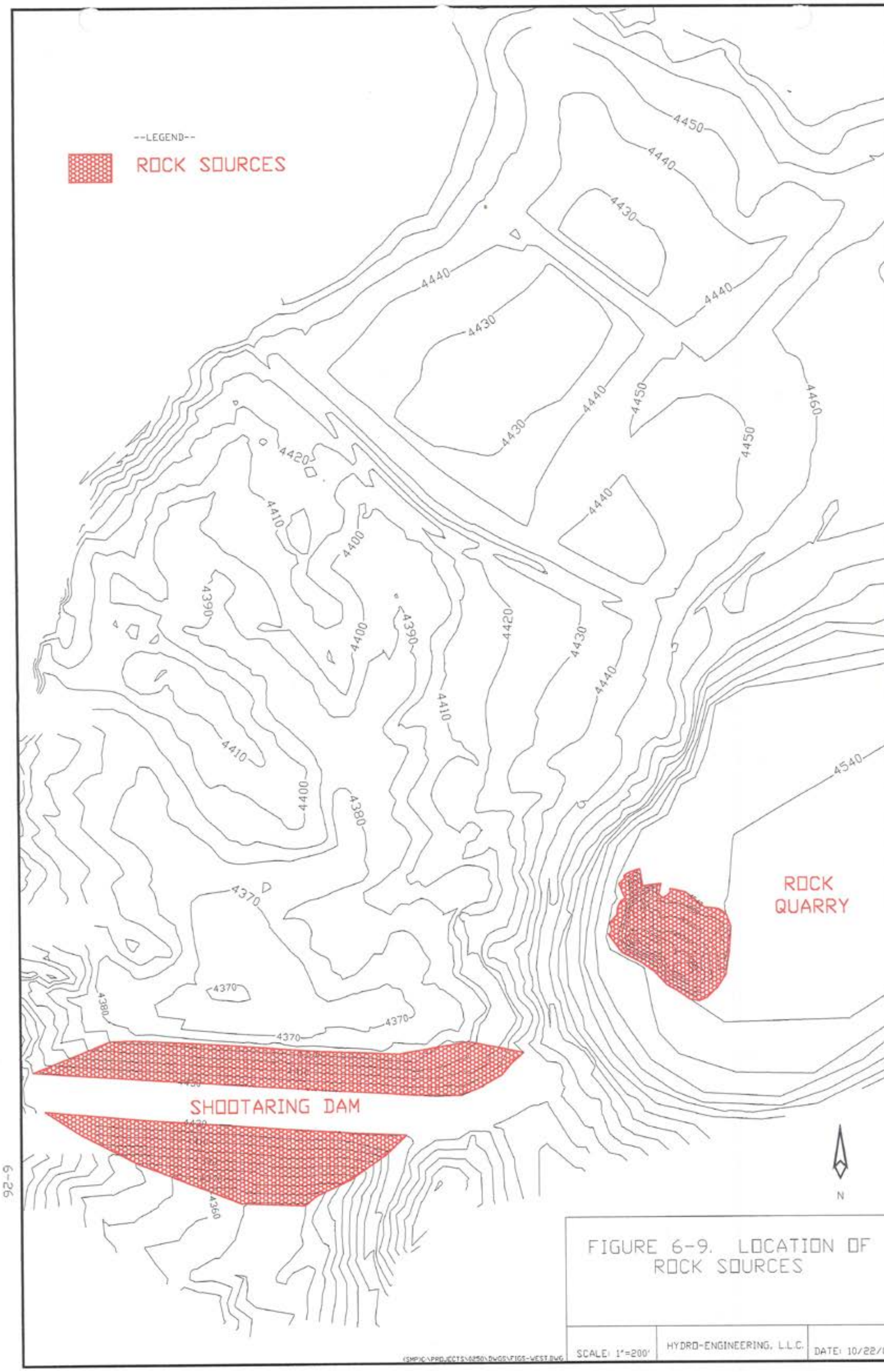


FIGURE 6-9. LOCATION OF ROCK SOURCES

6-26

7.0 WATER RESOURCE PROTECTION

The ground water conditions at this site have been defined in the initial Woodward-Clyde investigations and updated in Hydro-Engineering, LLC (1998, 1999 and 2000). Additional ground water monitoring data are presented in Hydro-Engineering, LLC (2001 and 2002). The uppermost ground water I the area of the tailings cell is in the Entrada sandstone with water levels approximately 140 feet below the land surface below the tailings cell area. The water quality is very good in the Entrada aquifer. The ground water has not been affected by the Shootaring tailings site; therefore no corrective action has been necessary at this site.

7.1 Groundwater

The tailings management plan for the Shootaring Canyon uranium project has been developed to prevent contamination of groundwater underlying the tailings disposal area. A clay lining system generally consisting of 24 inches minimum clay base was placed over the natural sandstone in the impoundment area to limit or prevent contaminant migration from the tailings impoundment into the foundation rock. At this time, the tailings are is dewatered of the drainable water except for a very small quantity that is draining at a very low rate.

Figure 7-1 presents the location of wells in the Shootaring tailings area. The wells that are completed in the upper portion of the Entrada are shown in red while wells that re completed in the middle and lower portions of the Entrada sandstone are shown in blue. Additional Upper Entrada wells were drilled on the downgradient side of the cross valley berm southeast and northwest of well RM7. New wells RM18 and RM19 were completed in the upper portion of the Entrada aquifer downgradient of the cross valley berm. Well RM20 was completed adjacent to RM8 also in the upper portion of the Entrada aquifer. Table 7-1 presents the completion information for these new wells. Shallow wells RM21 and RM22 were completed adjacent to deep wells RM18 and RM19 to determine if the ground water mound observed in wells RM8 and RM9 extend northward to the toe of the downsized tailings cell area. Table 7-1 also presents the completion information for RM21 and RM22, which are dry. The neutron and gamma logs for new wells RM18 and RM19 did not show a strong indication of saturation above the water table in the Entrada aquifer at these two locations. Shallow wells RM21 and RM22 were drilled while the driller was on site to conclusively show whether saturation exists above the Entrada water table in these areas. These neutron logs did not indicate the presence of a low permeability lense above the Entrada water table at these two wells. The neutron log for well RM20 does show a strong indication of saturation from a depth of 58 to 97 feet. Saturation above the Entrada water table is known to exist in this area based on shallow well RM8 located adjacent to well RM20. An updated neutron log was also conducted on well RM14 due to the deepening of this well since the previous neutron log. Figure 7-1D presents the updated neutron and gamma logs for well RM14. No visual indications of saturation were observed during the drilling of RM18 through RM22. Foam typically had to be added to the drilling process at depths of slightly less than 50 feet, which masks any evidence of saturation after its addition.

Figure 7-1E presents the neurtron and gamma logs for well RM8 which are similar to the neutron log from RM 20 until the probe reaches the water level in well RM8. The three geologic cross-sections that were included in the 1998 Ground-Water Hydrology report were updated and are presented in this section. Figure 7-1 shows the location of these

TABLE 7-1. BASIC DATA FOR THE SHOOTARING WELLS AND PIEZOMETERS.

WELL NAME	NORTH. COORD.	EAST. COORD.	CASING DIAMETER (in)	TOTAL DEPTH (ft-mp)	STICKUP (ft)	MP ELEV. (ft-msl)	WATER LEVEL DEPTH (ft-mp)	WATER LEVEL ELEVATION (ft-msl)	SLOTTED CASING (ft-lsd)	SAND PACK (ft-lsd)	PUMP INTAKE (ft-lsd)
						WELLS					
OW1A	57140	63730	1.0	300.0	0.2	4472.53	229.2	4243.33	200-300	-	—
OW1B	57140	63730	1.0	798.0	1.9	4474.23	448.2	4026.03	648-798	-	—
OW2	57094	63667	1.0	300.0	0.2	4470.70	222.9	4247.80	200-300	-	—
OW3	57046	63659	1.0	798.0	2.3	4470.78	453.2	4017.58	650-798	-	—
OW4	57035	63707	1.0	570.0	2.3	4472.54	213.5	4258.99	435-570	-	—
RM1	59307	61827	3.0	487.0	2.2	4449.20	176.5	4272.67	220-480	157-487	106
* RM2	57731	63040	3.0	520.0	1.6	4519.76	258.2	4261.51	260-520	250-520	—
RM2R	57924	63142	5.0	300.0	1.2	4504.86	242.6	4262.26	250-300	242-300	273
* RM3	57193	60647	6.0	540.0	1.8	4461.32	214.8	4246.52	230-540	190-540	246
* RM4	56472	61099	3.0	500.0	3.5	4395.50	155.8	4239.70	190-490	115-500	176
* RM4R	56358	61086	5.0	160.0	1.0	4368.32	128.6	4239.72	110-160	105-160	157
* RM5	56416	61286	3.0	440.0	3.6	4379.12	140.3	4238.82	150-430	130-440	172
* RM6	56348	61481	3.0	460.0	2.3	4374.57	136.5	4238.07	175-455	110-460	174
RM7	57904	61645	3.0	219.5	2.0	4395.86	140.5	4255.33	187-217	177-217	200
RM8	57204	61576	3.0	79.1	3.1	4381.77	58.25	4323.52	57-77	47-77	—
* RM9	56767	61363	3.0	82.8	1.2	4369.31	61.30	4308.01	62-82	52-82	—
* RM10	56286	61272	5.0	99.0	2.0	4343.57	95.30	4248.27	57-97	53-97	—
* RM11	56594	60769	5.0	240.0	2.0	4436.14	184.7	4251.44	140-180	5-180	203
									180-240#	-	
RM12	59477	61791	5.0	157.0	1.3	4415.95	142.7	4273.22	117-157	110-157	156
* RM13	56648	61996	5.0	270.0	2.0	4434.81	189.6	4245.21	140-180	5-180	219
									180-270#	-	
RM14	58419	61368	5.0	260.0	1.5	4450.84	192.2	4258.61	134-174	127-174	253
									174-260#	-	
* RM15	56311	61354	5.0	460.0	1.9	4343.75	107.7	4236.05	379-459	95-459	157
* RM16	56615	60772	5.0	296.0	1.2	4434.95	194.6	4240.35	246-296	240-296	255
* RM17	56636	61993	5.0	290.0	0.7	4433.58	190.0	4243.58	240-290	235-290	248
RM18	57833	61851	5.0	243.3	1.3	4421.56	164.4	4257.15	162-242	149-242	232
RM19	58077	61524	5.0	236.3	1.3	4409.50	152.7	4256.74	155-235	139-235	219
RM20	57208	61592	5.0	212.6	1.6	4380.83	129.9	4250.93	131-211	120-212	201
RM21	57843	61851	5.0	141.3	1.3	4421.64	Dry	4281.64	110-140	100-140	—
RM22	58088	61513	5.0	120.8	0.8	4410.52	Dry	4290.52	90-120	80-120	—
WW1	57144	63677	6.0	870.0	-2.8	4454.79	---	---	635-870#	-	—
WW2	56562	63086	6.0	1000.	-3.4	4471.61	---	---	602-1000	-	—
						TAILINGS WELLS					
T4	58456	61953	2.0	20.0	1.2	4431.20	Dry	4411.20	12.9-17.9	10-18	—
T5	58371	61891	2.0	10.0	2.5	4425.00	Dry	4415.00	2.5-7.5	0.7-8	—
T6	58133	61801	2.0	11.7	2.9	4429.00	Dry	4417.30	3.8-8.8	1-9	—
						PIEZOMETERS					
PZ1	56598	61022	1.0	87.0	2.0	4434.51	---	---	75-85	2-85	—
PZ2	56580	61327	1.0	88.0	2.0	4434.74	---	---	76-86	3-86	—
PZ3	56564	61575	1.0	88.0	2.0	4435.34	---	---	76-86	3-86	—
* PZ4	56271	61383	1.0	25.0	2.0	4347.17	Dry	4320.92	13-23	2-23	—
* PZ5	56301	61275	1.0	25.0	2.0	4344.79	Dry	4318.49	13-23	1-23	—

TABLE 7-1. BASIC DATA FOR THE SHOOTARING WELLS AND PIEZOMETERS. (cont.)

WELL NAME	NORTH. COORD.	EAST. COORD.	CASING DIAMETER (in)	TOTAL DEPTH (ft-mp)	STICKUP (ft)	MP ELEV. (ft-msl)	WATER LEVEL DEPTH (ft-mp)	WATER LEVEL ELEVATION (ft-msl)	SLOTTED CASING (ft-lsd)	SAND PACK (ft-lsd)	PUMP INTAKE (ft-lsd)
* PZ6	56332	61167	1.0	25.0	2.0	4362.50	Dry	4336.90	13-23	2-23	—

NOTE: Wells RM1 through RM6, RM15 through RM17, OW1A and OW2 are completed in the Entrada Aquifer
Wells RM2R, RM4R, RM7 through RM14 and PZ4 through PZ6 are completed in the Upper Entrada Sandstone
Wells WW1, WW2, OW1B and OW3 are completed in the Navajo Aquifer
Well OW4 is completed in the Carmel Aquitard
Piezometers PZ1 through PZ3 are Dam Piezometers
mp = measuring point; lsd = land surface datum; msl = mean sea level
# = open hole
* = Abandoned Well
Above data compiled from physical measurements, records and site surveys.

cross-sections. Cross-section 1-1' which is presented in Figure 7-2 goes along the downstream side of the Shootaring Dam. Cross-section 2-2 goes across the downstream side of the cross valley berm adjacent to the tailings cell and down to monitoring well RM3. Figure 7-3 presents geologic ·cross-section 2-2'. This cross-section was extended on the east up to new shallow monitoring well RM2R and changed to go along the cross valley berm from well RM18 to RM7 to RM19 to RM14 and then south to monitoring well RM3. This adjustment was made to allow the presentation of wells RMI4, RMI8 and RM19 on this cross-section. The new neutron log for well RM14 replaced the original log for well RM14 on Figure 7-3 because this well was deepened after the initial log measurement. None of the neutron logs of the wells (RM18, RM7, RM19 arid RM14) along the cross valley berm indicate the existence of a low permeability zone above the Entrada water table· in this area. Cross-section 3-3' goes from the downstream edge of the Shootaring Dam through the cross valley berm and the tailings cell and to the background monitoring wells RMl and RM12 (see Figure 7-4). The log of new well RM20, which is adjacent to RM8, replaces the RM8 log because the log for we11 RM20 is deeper. Figure 7-1 shows the location of the limits of the existing tailings (blue line) and edge of the designed tailin cell. Figure 7-4 shows the design reclamation surface in red and the northern and southern limits of the designed tailings cell on this cross section. The top of the existing clay liner below the tailings is shown in blue in the tailings cell area. These geologic cross-sections show neutron logs at two different scales. The neutron log below the water table is printed in red at an expanded scale (see scale definition ·on the log). The range of the two scales for the logs for wells RM6 and RM12 are different than the remainder of the logs. The areas of lower permeability (K) sandstone were interpreted from the neutron logs. A magenta pattern is shown where the lower permeability sandstone is indicated by the neutron logs. This lower permeability sandstone exists in the Shootaring Dam area and upstream of the dam but does not extend up to well RM20 or up to the cross valley berm and tailings cell. A thin lower permeability lense is thought to cause the saturation in RM8 based on the RM20 log. Some lower permeability Sandstone also exists in the area of upgradient monitoring well RM1 but does not extend to RM12. The neutron log for RMI indicates that this material does not have a permeability as low as the sandstone at RM15. The small head difference between RMl and RM12 also indicates that the upper sandstone at RM1 is more permeable. No lower permeability material was interpreted in the area of cross-section 2-2' which is near the cross valley berm and tailings cell area. Tailings well T4 is shown on the cross-section in Figure 7-4 and this well illustrates that the existing tailings thickness is very small.

The well depth is shown with a vertical yellow line with the slotted or open hole interval shown with short black horizontal line pattern. The limits of the higher water-level elevations in the upper Entrada were defined prior to the deepening of wells RMll, RM13 and RM14. Wells RM13 and RM14 were dry prior to deepening these wells. A note has been added to the geologic cross-section to show the depth of these wells prior to deepening. RM11 contained a very few feet of water in the well prior to deepening this well. Higher water-level elevation, therefore, does not exist in wells RM14, RM21 and RM22 as it does in RM8 and RM9.

The piezometric surface for 2003 was updated on the three cross-sections. A cyan water-level elevation line is shown for the Entrada aquifer. The green piezometric surface line is shown on the cross-sections for the upper lower permeability Entrada. The higher water level in the Upper Entrada is approaching the Entrada aquifer piezometric surface at RMl0 but is seventy feet higher in elevation upstream of the Shootaring Dam. The Upper Entrada head approaches the Entrada aquifer head between wells RM8 and RM7 (see Figure 7-4). Figure 7-5 also presents the water-level elevation for the Upper Entrada and the Entrada aquifer for 2003. The blue contours show that the piezometric surface in the Entrada aquifer is highest at upgradient well RMl at slightly above 4272 ft-msl and lowest downstream of the Shootaring Dam at less than an elevation of 4240 ft-msl. Water-level elevation of the upper lower permeability Entrada is shown in red on the Figure 7-5. This piezometric surface shows a mound around RM8 and RM9 with steep gradients extending outward from these two wells. The Upper Entrada saturation zone is very thin at RMIO, RMll and RM13. Water levels in the Upper Entrada wells RM7, RM12, RM14, RM18, RMI9, RM20 and RM2R fit the main Entrada piezometric surface showing that the Upper Entrada and the main aquifer have very similar heads in the tailings cell area.

The latest 2002 water-quality data is also presented on the three cross-sections. The water-quality data is listed on the cross-section for wells shown on the cross-section and are listed in the same order as presented on the cross-section. For example, Figure 7-4, cross-section 3-3' presents the water quality for RM10, RM15, RM7, RM1 and RM12. Water-quality data was not collected from RM8 and RM9 in 2002 and therefore were not presented in the tabulation. Water-quality data shows that the quality of water is very good with TDS varying from a low of 119 at RM11 to a high of 354 mg/1 from well RM12. As expected, chloride concentrations are very low in this water, from a low of 4 at RM4R to a high of 33 mg/1 at RM12. Background well RM12 has the highest concentrations for these two constituents which has been useful in defining the upper range of natural concentrations of these constituents. The arsenic concentration is slightly higher in wells RM3, RM11 and RMlO. The chloride concentrations and other conservative ions at these three wells are well within the natural range and therefore these arsenic concentrations are also thought to be natural. The 2002 water-quality data does not indicate any impacts from the Shootaring tailings. Future concentrations along with previous 20 years of data from all of the Shootaring wells are important in defining the range of background concentrations at this site.

At the project site, net evaporation from exposed water surfaces will average approximately 70 inches (178 cm) per year, which is equivalent to approximately 3.6 gallons (13.6 l/min) per minute per acre of exposed surface.

Since the tailings management plan provides a means for drainage of all excess tailings liquids, no significant amount of free tailings liquid will remain in the impoundment at project termination. Presently no free tailings liquid has been measured in the four tailings wells in the existing tailings. Also, after the project is terminated, normal evaporation from the tailings cap system will dispose of the incident precipitation, including runoff. Under present conditions with a land surface with a depression and without a clay cap, the drainage system collects only a very small rate of water after rainfall events (see Section 3.2 for details). A very limited potential therefore exists for groundwater contamination from this project, and the requirements for surveillance of the groundwater in the area will be minimal. The monitoring wells located immediately downgradient of the disposal cell perimeter (RM7, RM14, RM18 and RM19) will be maintained and be available for subsequent groundwater monitoring.

7.1.1. Drainage Through Liner

The Entrada sandstone underlying the disposal system has a high calcite (calcium carbonate) content and an average horizontal hydraulic conductivity (permeability) of 7 x 10-5 cm/sec (0.2 ft/day, see Hydro-Engineering 1998), as computed from field test data. The vertical hydraulic conductivity is probably less than the horizontal, perhaps less than one tenth of the horizontal value. This high calcite content has neutralized any acid (pH 1-2) tailings solution that may have contacted the calcite. Monitoring well data indicates that the acidic tailings solution has not penetrated the underlying sandstone. Natural neutralization raises the pH, which in turn precipitates the radionuclides and heavy metals present in the tailings liquids. A high TDS would exist in any water after neutralization. Major constituent monitoring does not indicate any water quality impact. For a more complete discussion on the geology and chemical properties of the underlying material, refer to Woodward-Clyde Consultants (1978a and 1979) studies in the preliminary and final ·geotechnical studies of the area. The ground water monitoring at the tailings site does not show effects from the existing tailings. The ground-water quality is very good in the Entrada aquifer in the tailings area (see Hydro-Engineering 2002). The water quality concentrations in the Entrada aquifer have not changed enough to indicate any impact and reflect only background variations. The potential for impact will be reduced even further with the addition of the clay cap over the tailings cell.

The area north of the existing cross valley berm has been lined with a clay blanket of generally not less than two-feet thickness. The clay blanket has been overlain with sandy material covered with gravel, which is designed to collect slimes. Within the sand layer and adjacent to the clay liner are drainage pipes which drain to a collection sump to prevent the development of static head on the clay liner. The collection sump, located downstream of the cross valley berm, is equipped with a pump. The liquid in the sump is pumped to lined surface evaporation pond placed on top of tailings within the impoundment. The sump will remain active during reclamation until commencement of the placement of the final clay cap. At that time, the drains will be plugged.

7.1.2 Monitoring Threshold Values

The NRC has selected the following threshold values: Arsenic = 0.022 mg/1, Chloride= 40 mg/1, Selenium= 0.022 mg/l, and pH= 6.8 standard units. Uranium is compared to the 10 CFR 20, Appendix B effluent concentration of 3E-7 µCi/ml (300 pCi/1 or 0.44 mg/1). The up-gradient well RMl is located immediately north of the tailings impoundment. The compliance wells are RM4, RM5, and RM6 as shown on Figure 7-1. Uranium One Americas recommends RM7, RM18 and RM19 to be designated as compliance wells due to their much closer locations to the disposal cell. Wells RM18, RM19 and RM20 are new wells which are shown on Figure 7-1. Well RM20 is located adjacent to well RM8 and is completed in the upper portion of the Entrada aquifer and used with well RM8 to define the vertical gradient in this area. The vertical head difference between wells RM8 and RM20 is 72.6 feet. This indicates an average gradient between the center of these two well screens of 0.69 feet/feet (72.6/104). Figure 7-1 also shows the locations of two new wells, RM21 and RM22, adjacent to wells RM18 and RM19. The neutron logs from wells RM18 and RM19 did not show a strong indication of a saturated mound above the Entrada piezometric surface at wells RM18 or RM19, but the two shallow wells were added while the driller was on site to confirm the lack of saturation. Wells RM21 and RM22 are dry.

The Shootaring Canyon ground-water monitoring program is proposed to consist of semi-annual sampling for the following parameters:

PARAMETER LISTING

pH (field)	Conductivity (field)	Total Dissolved Solids
Chloride	Sulfate	Arsenic
Barium	Cadmium	Chromium
Copper	Lead	Mercury
Molybdenum	Selenium	Silver
Zinc	Ammonia	Fluoride
Nitrate plus Nitrite	Uranium	

Ground-water sampling at the Shootaring site is still being used to define the variation in natural concentrations at this site. The following wells will be used with wells RM7, RMJ 8 and RM19 to continue to define the background concentrations:

Upgradient wells RM1 and RM12 are very useful in defining upgradient concentrations at this site but these additional wells will also define variation in natural concentrations. They also will be used to determine whether the tailings cell has any effect on the Entrada aquifer.

Wells RM4, RM4R, RMS, RM6, RM9, RMlO, RMll, RM13, RMIS, RM16 and RM17 are not included in the program due to the difficulty in preserving these wells during construction operations and the breaching of the Shootaring Dam. Each of these wells were abandoned in October of 2003. Well RM2 was abandoned because it is not possible to pump a sample from the well, and it was located near well RM2R which is included in the monitoring program. Well RM3 was also abandoned due to its distance from the taiJings cell. Piezometers PZ4, PZS and PZ6, which were completed in the upper shallow· portion of the Entrada sandstone, were also abandoned. No saturation has been detected in these we1ls and it is extremely unlikely that saturation will occur due to the shallow completion of the wells. These wells were completed for the Shootaring Dam stability monitoring program. Figure 7-1 shows which wells have been abandoned. Also, dam piezometers PZI, PZ2 and PZ3 are proposed to be abandoned due to the Shootaring Dam breaching.

7.2 Surface Water

After the site has been reclaimed, the clay barrier and cover will prevent surface water from coming into contact with the contaminated material. In addition, much of the surface water will be diverted away from the tailings disposal cell. Therefore, the water quality of the surface runoff should be the same as the runoff water quality outside of the cell area.

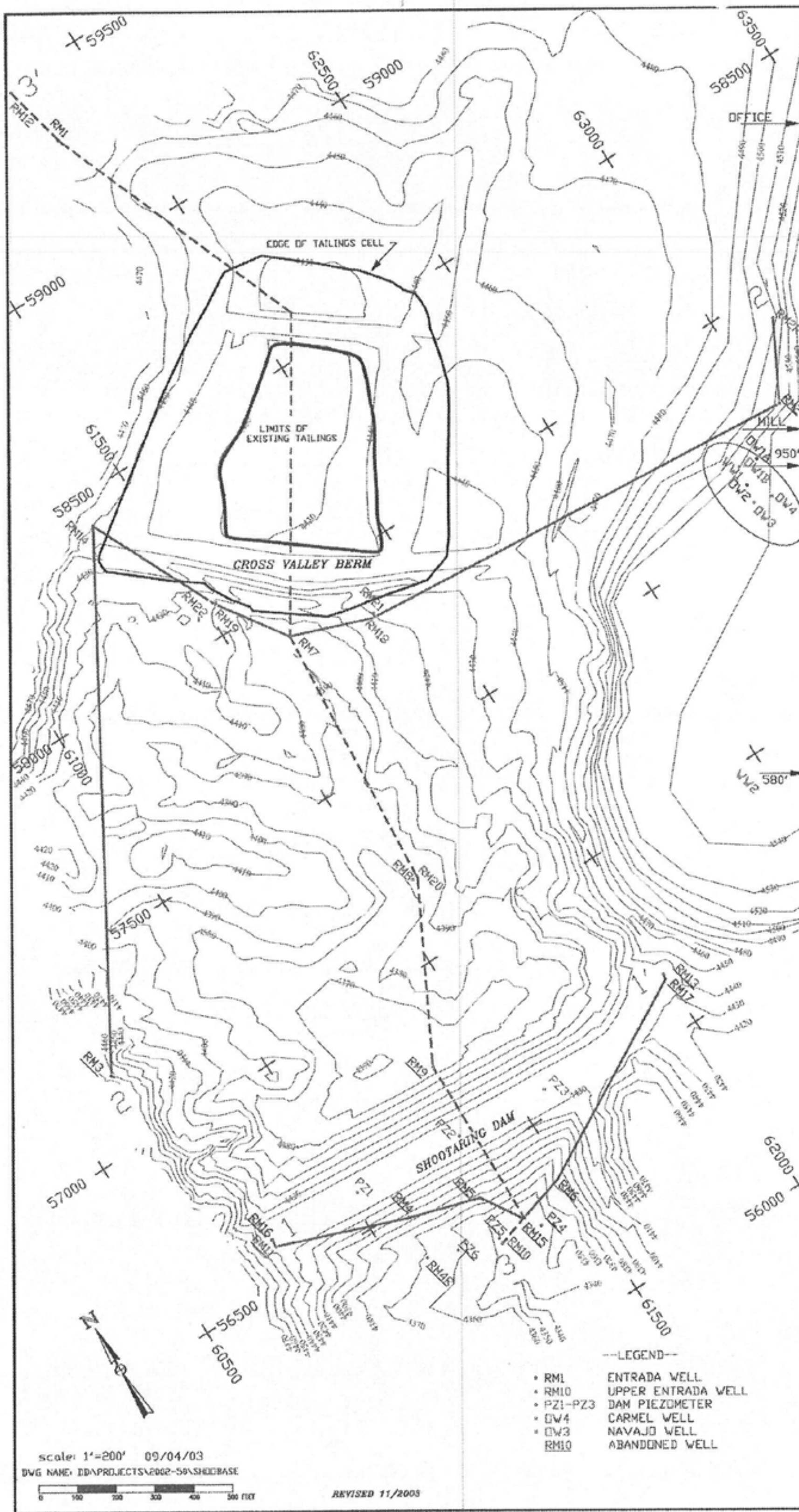


FIGURE 7-1. LOCATION OF WELLS AND GEOLOGIC CROSS SECTIONS

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THAT CAN BE VIEWED AT THE RECORD TITLED:

FIGURE 7-1
"LOCATION OF WELLS AND GEOLOGIC CROSS SECTIONS"

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D-01

FIGURE 7-1A. NEUTRON AND GAMMA LOGS FOR WELL RM18.

Southwest Geophysical Services, Inc.

COMPANY PLATEAU RESOURCES
WELL ID RM-18
FIELD SHOOTARING MILL
COUNTY GARFIELD STATE UTAH

TYPE OF LOG: GAMMA - NEUTRON LOG

OTHER SERVICES: NONE

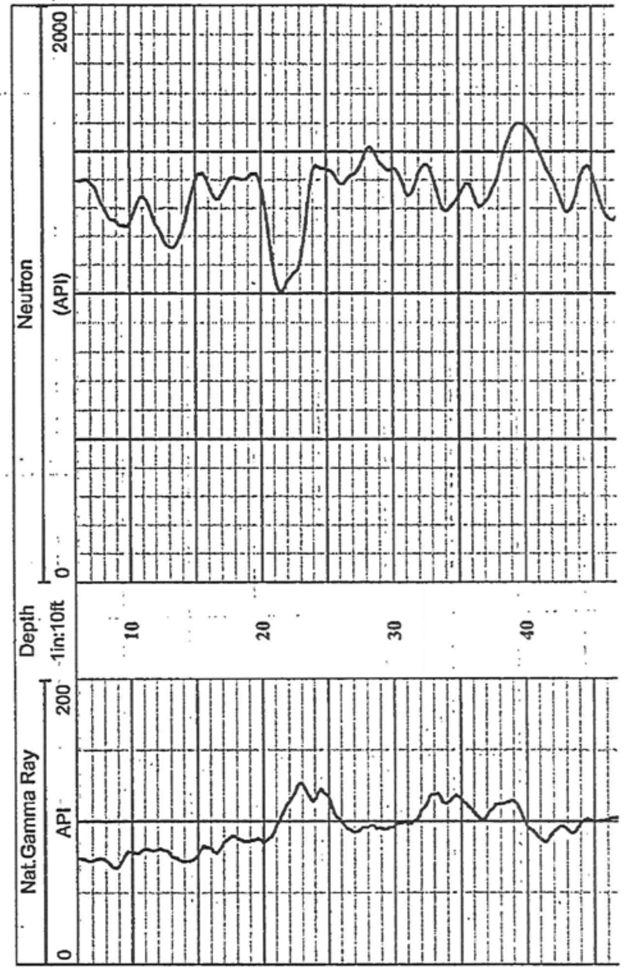
LOCATION

SEC TWP RGE

PERMANENT DATUM		ELEVATION	K.B.
LOG MEAS. FROM	GROUND LEVEL	ABOVE PERM. DATUM	D.F.
DRILLING MEAS. FROM			G.L.

DATE	10-27-03	TYPE FLUID IN HOLE	FORMATION FLUID
RUN No	1	SALINITY	
TYPE LOG	GAMMA - NEUTRON	DENSITY	
DEPTH-DRILLER	242 FT	LEVEL	164 FT
DEPTH-LOGGER	243.5 FT	MAX. REC. TEMP.	
BTM LOGGED INTERVAL	243 FT		
TOP LOGGED INTERVAL	SURFACE		
OPERATING RIG TIME			
RECORDED BY	Q. FROST		
WITNESSED BY	FRED CRAFT		

RUN	BOREHOLE RECORD			CASING RECORD			
NO.	BIT	FROM	TO	SIZE	WGT.	FROM	TO
1	7 7/8"	SURFACE	242 FT	5"	PVC	SURFACE	242 FT



Revised November 2003

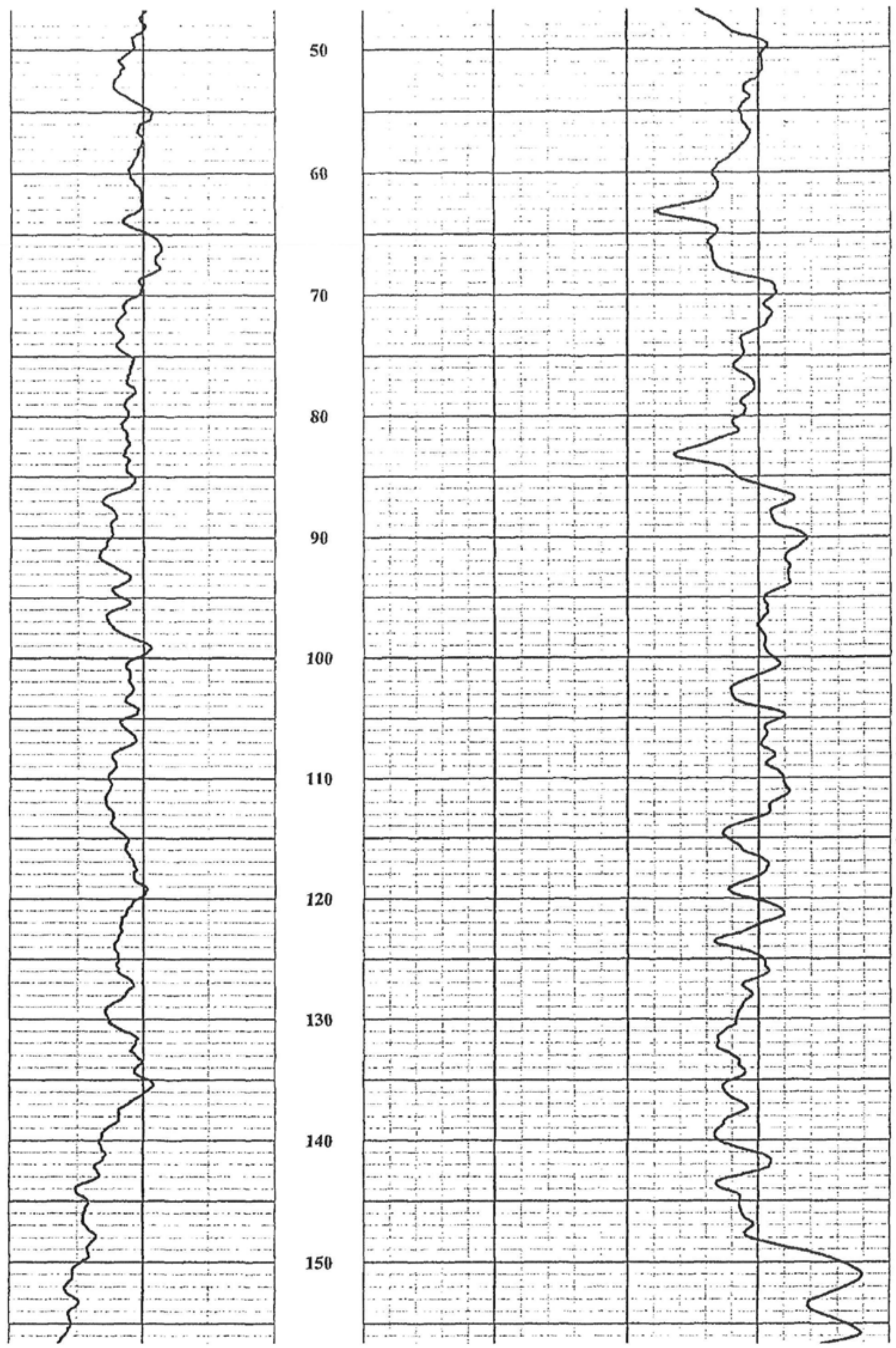


FIGURE 7-1A. NEUTRON AND GAMMA LOGS FOR WELL RM18, (continued).

Revised Novem

FIGURE 7-1A. NEUTRON AND GAMMA LOGS FOR WELL RM18; (continued).

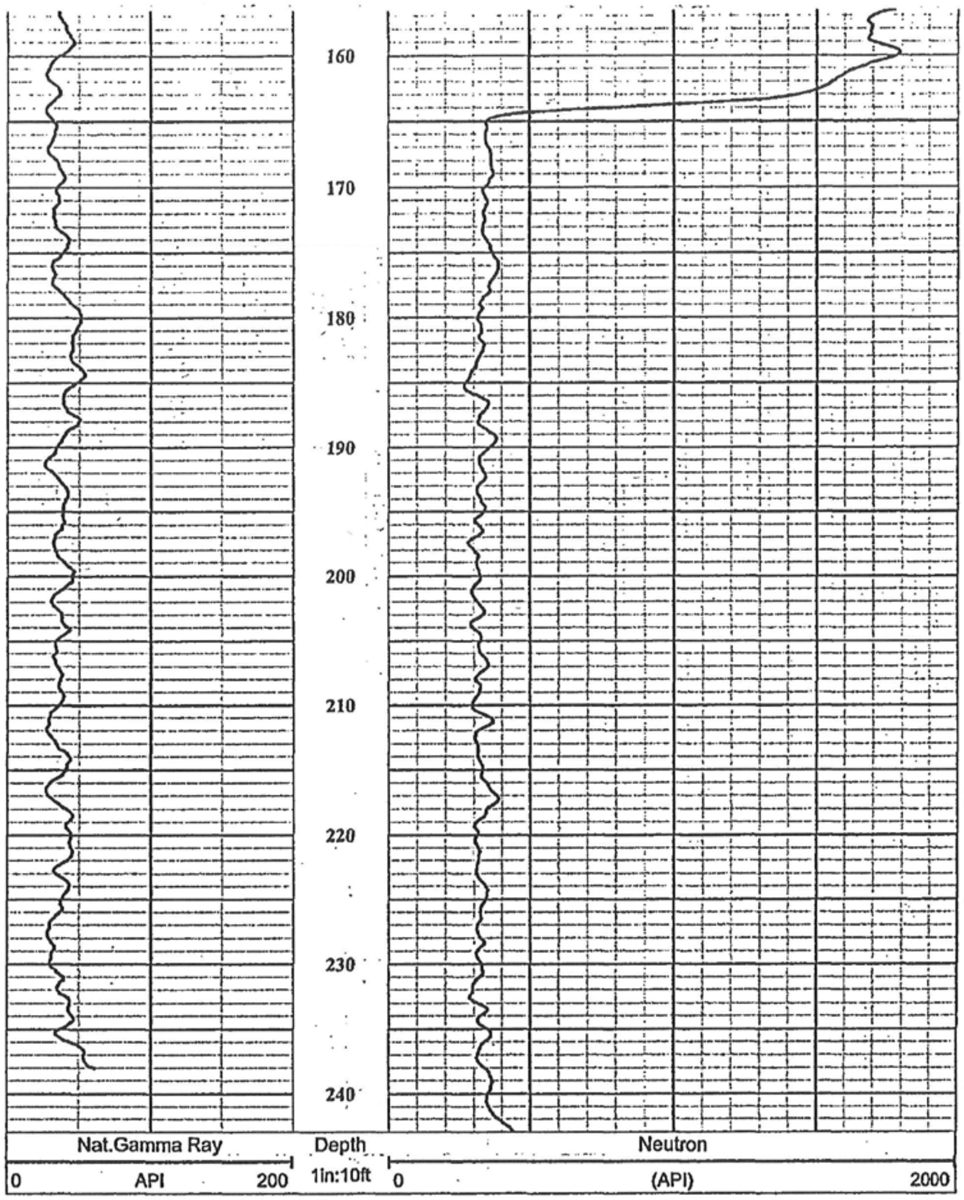


FIGURE 7-1B. NEUTRON AND GAMMA LOGS FOR WELL RM19.

Southwest Geophysical Services, Inc.

COMPANY PLATEAU RESOURCES
WELL ID RM-19
FIELD SHOOTARING MILL
COUNTY GARFIELD STATE UTAH

TYPE OF LOG: GAMMA - NEUTRON LOG

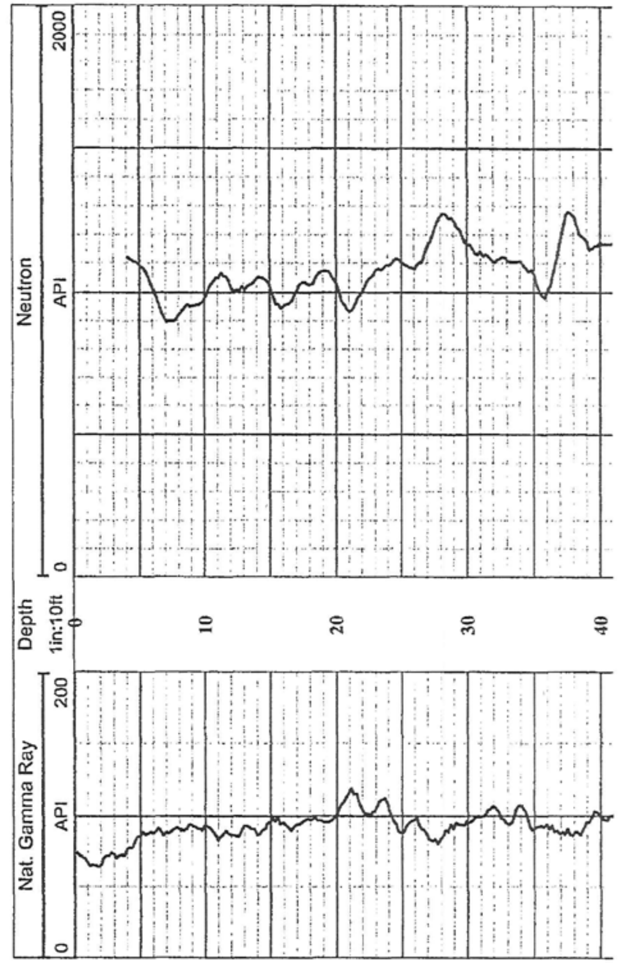
OTHER SERVICES: NONE

LOCATION

SEC TWP RGE

PERMANENT DATUM		ELEVATION	K.B.
LOG MEAS. FROM	GROUND LEVEL	ABOVE PERM. DATUM	D.F.
DRILLING MEAS. FROM			G.L.
DATE	10-28-03	TYPE FLUID IN HOLE	FORMATION FLUID
RUN No	1	SALINITY	
TYPE LOG	GAMMA - NEUTRON	DENSITY	
DEPTH-DRILLER	235 FT	LEVEL	154 FT
DEPTH-LOGGER	235 FT	MAX. REC. TEMP.	
BTM LOGGED INTERVAL	235 FT		
TOP LOGGED INTERVAL	SURFACE		
OPERATING RIG TIME			
RECORDED BY	K. MITCHELL		
WITNESSED BY	FRED CRAFT		

RUN	BOREHOLE RECORD			CASING RECORD			
NO.	BIT	FROM	TO	SIZE	WGT.	FROM	TO
1	7 7/8"	SURFACE	TOTAL DEPTH	5"	PVC	SURFACE	TOTAL DEPTH



Revised Novemb[illegible] '03

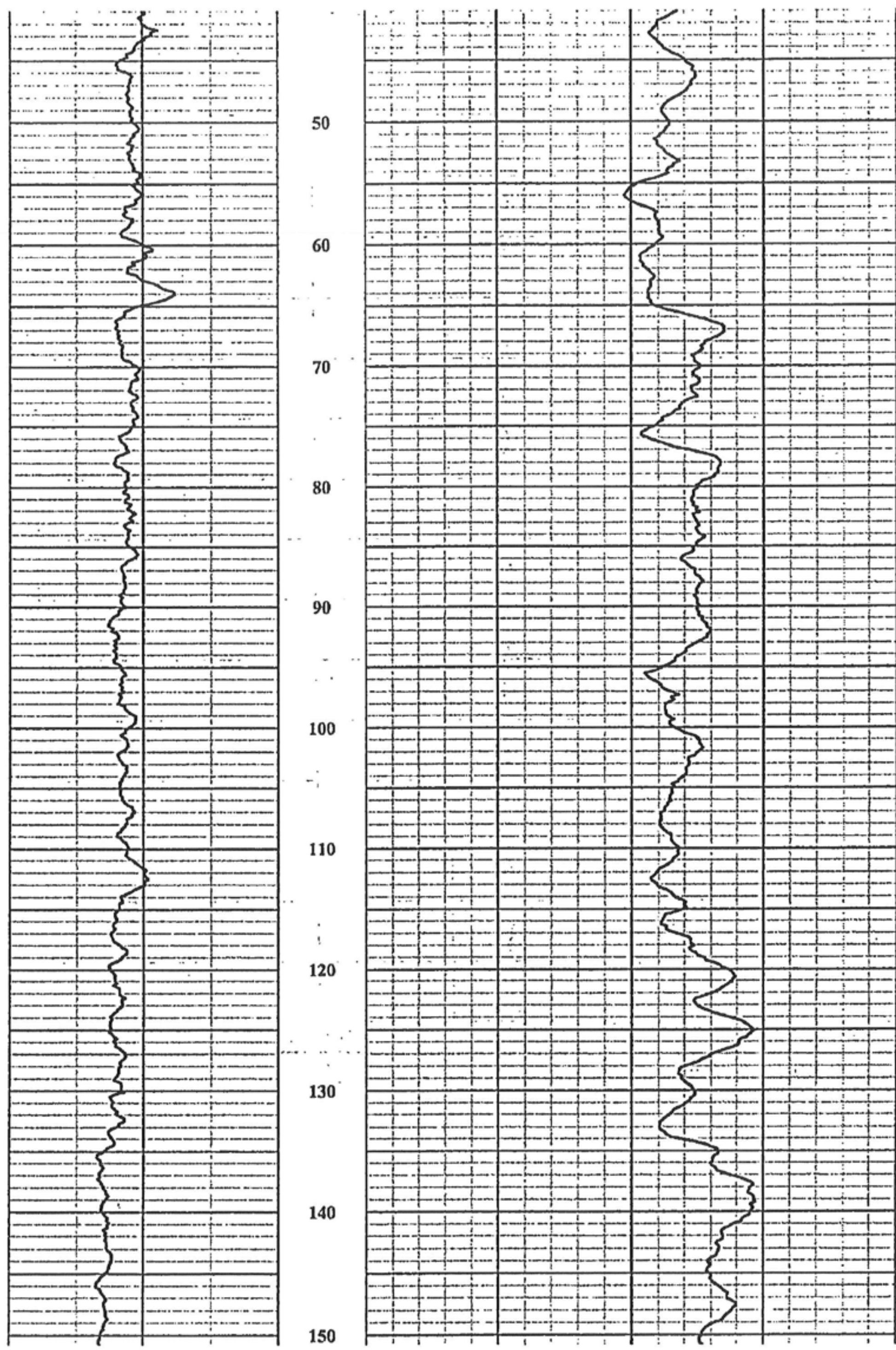
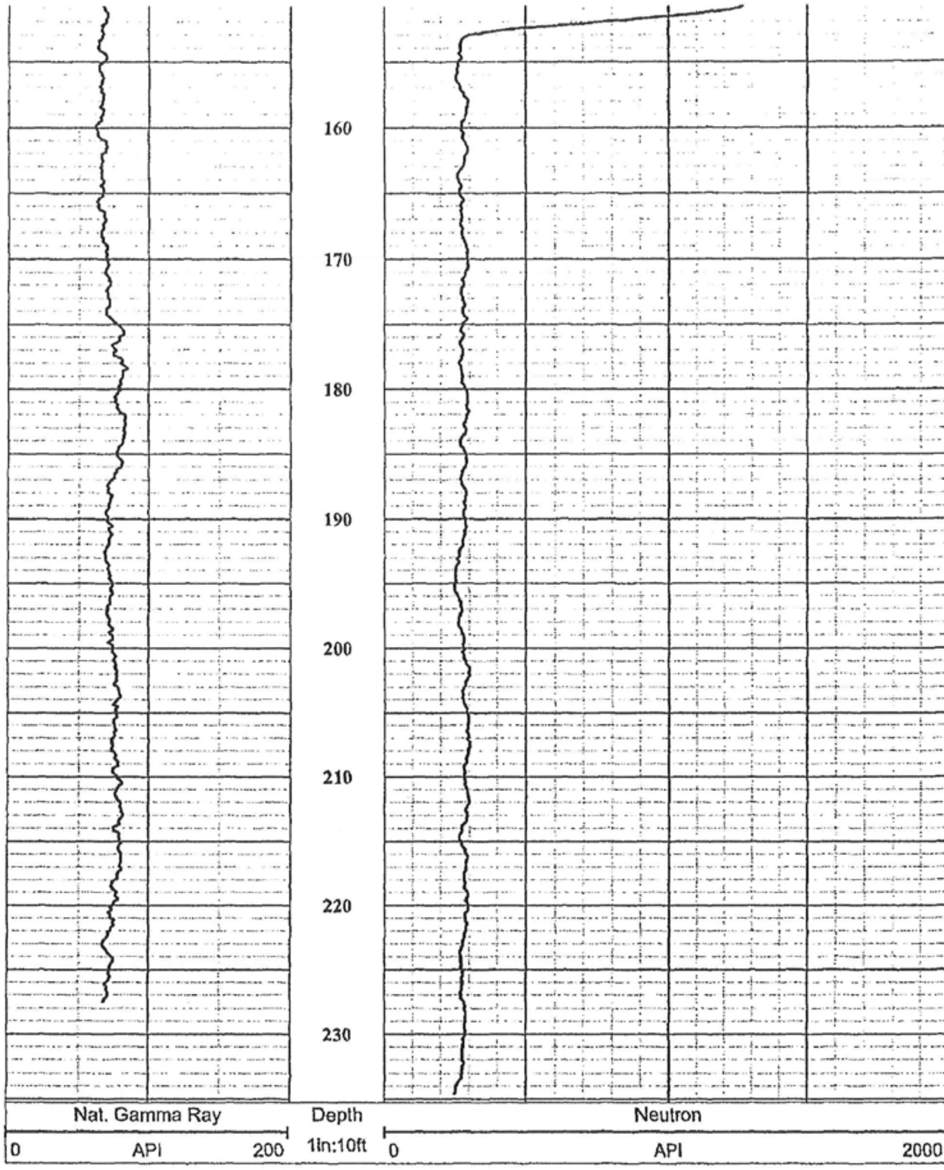


FIGURE 7-1B. NEUTRON AND GAMMA LOGS FOR WELL RM19, (continued).

7-1

Revised November 200

FIGURE 7-1B. NEUTRON AND GAMMA LOGS FOR WELL RM19, (continued).



Revised Novem 03

FIGURE 7-1C. NEUTRON AND GAMMA LOGS FOR WELL RM20.

Southwest Geophysical Services, Inc.

COMPANY PLATEAU RESOURCES
WELL ID RM-20
FIELD SHOOTARING MILL
COUNTY GARFIELD STATE UTAH

TYPE OF LOG: GAMMA - NEUTRON LOG

OTHER SERVICES NONE

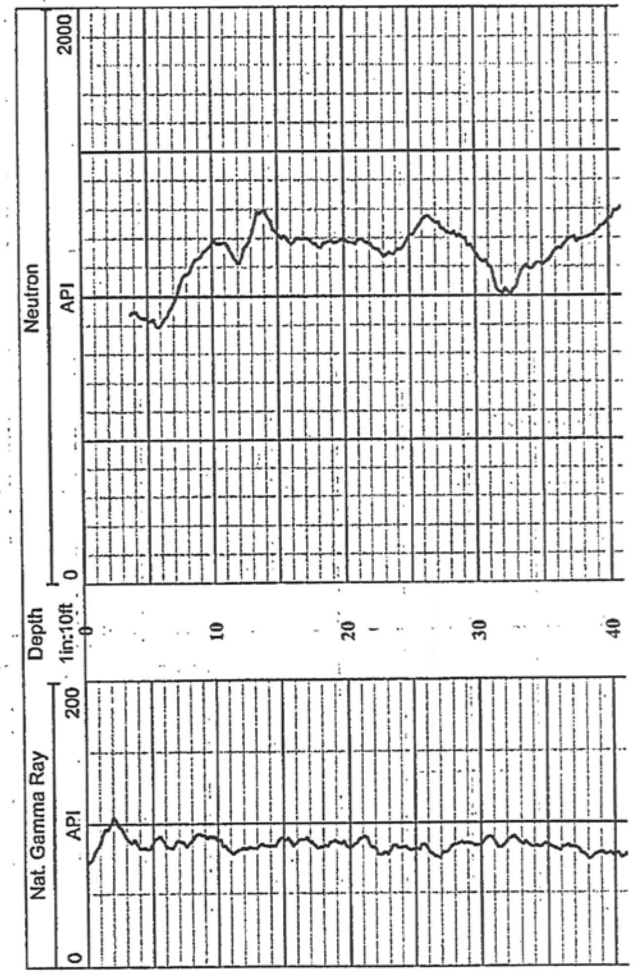
LOCATION

SEC TWP RGE

PERMANENT DATUM		ELEVATION		K.B.
LOG MEAS. FROM	GROUND LEVEL	ABOVE PERM. DATUM		D.F.
DRILLING MEAS. FROM				G.L.

DATE	10-28-03	TYPE FLUID IN HOLE	FORMATION FLUID
RUN No	1	SALINITY	
TYPE LOG	GAMMA - NEUTRON	DENSITY	
DEPTH-DRILLER	211 FT	LEVEL	127 FT
DEPTH-LOGGER	211 FT	MAX. REC. TEMP.	
BTM LOGGED INTERVAL	211FT		
TOP LOGGED INTERVAL	SURFACE		
OPERATING RIG TIME			
RECORDED BY	K. MITCHELL		
WITNESSED BY	FRED CRAFT		

RUN	BOREHOLE RECORD			CASING RECORD			
NO.	BIT	FROM	TO	SIZE	WGT.	FROM	TO
1	7 7/8"	SURFACE	TOTAL DEPTH	5"	PVC	SURFACE	TOTAL DEPTH



7-15

Revised November 2003

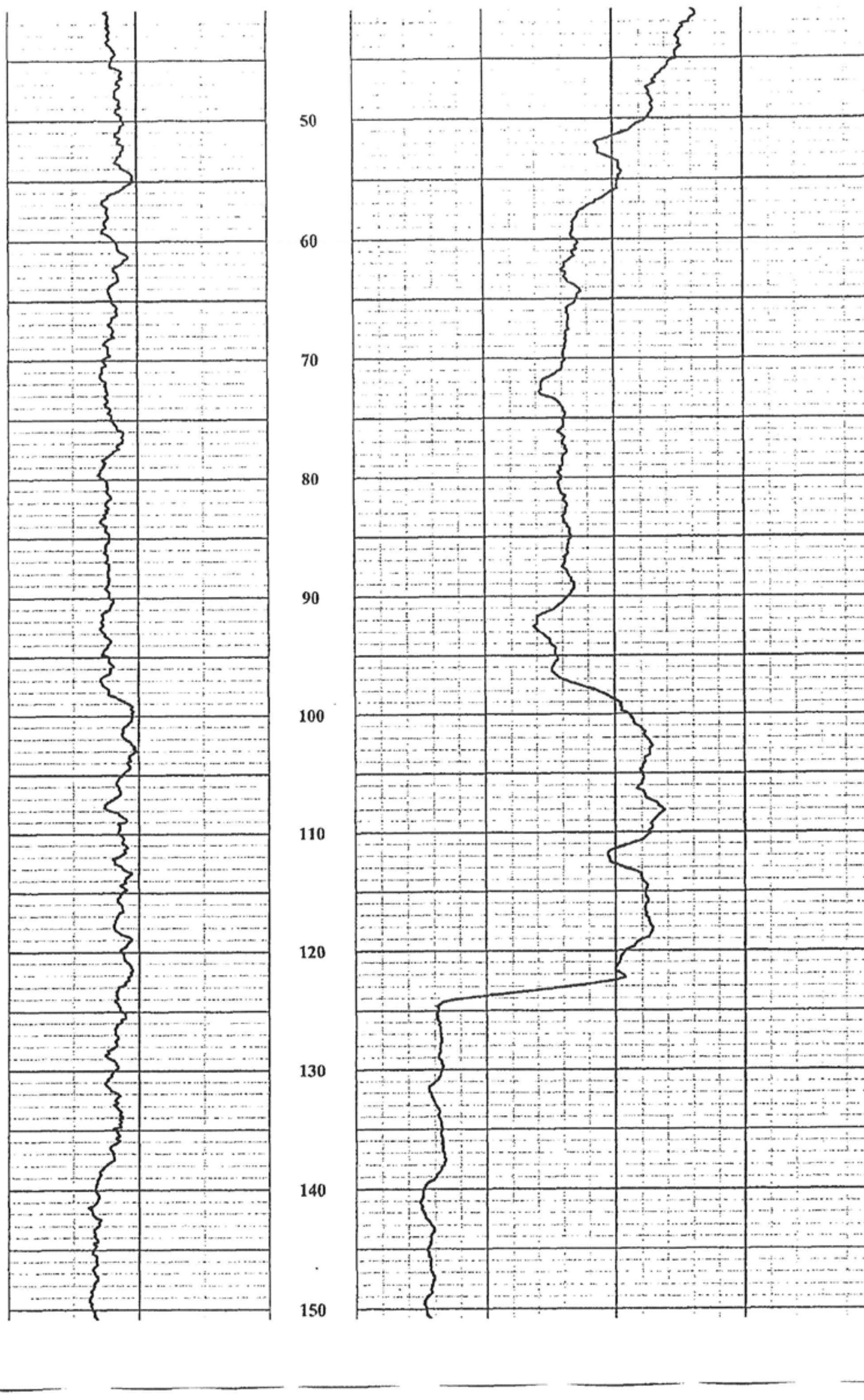


FIGURE 7-1C. NEUTRON AND GAMMA LOGS FOR WELL RM20, (continued).

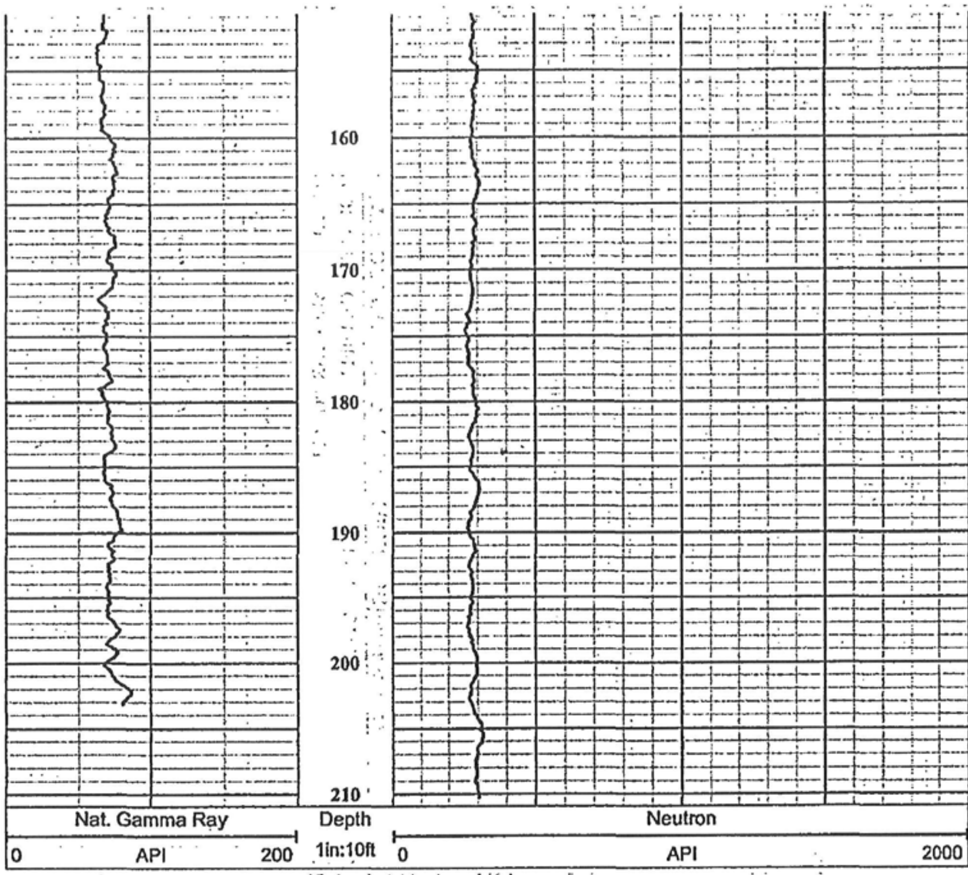


FIGURE 7-1C. NEUTRON AND GAMMA LOGS FOR WELL RM20, (continued).

FIGURE 7-1D. NEUTRON AND GAMMA LOGS FOR WELL RM14.

Southwest Geophysical Services, Inc.

COMPANY PLATEAU RESOURCES
WELL ID RM-14
FIELD SHOOTARING MILL
COUNTY GARFIELD STATE UTAH

TYPE OF LOG: GAMMA - NEUTRON LOG

OTHER SERVICES: NONE

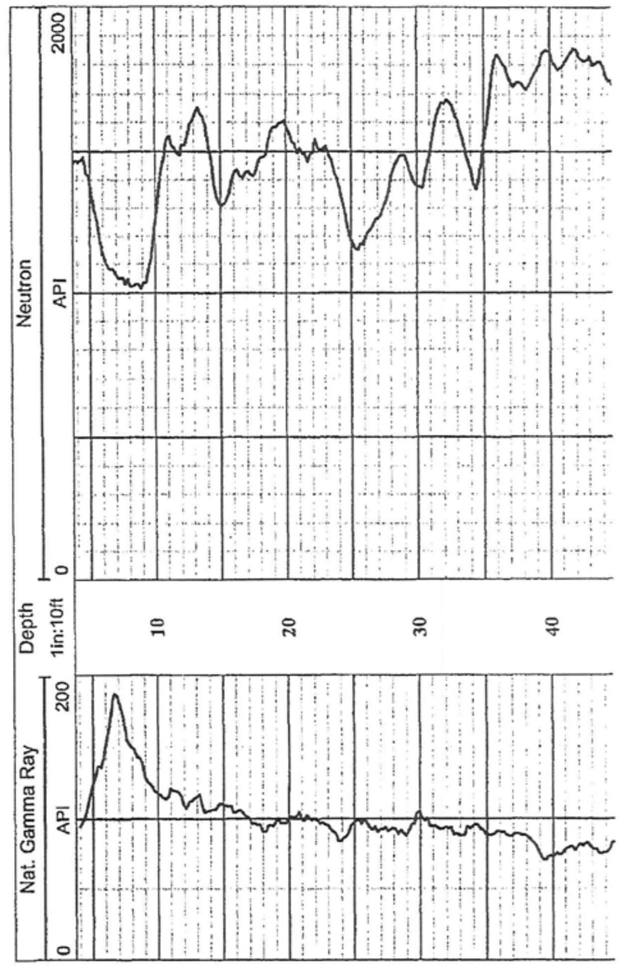
LOCATION

SEC TWP RGE

PERMANENT DATUM		ELEVATION	K.B.
LOG MEAS. FROM	GROUND LEVEL	ABOVE PERM. DATUM	D.F.
DRILLING MEAS. FROM			G.L.

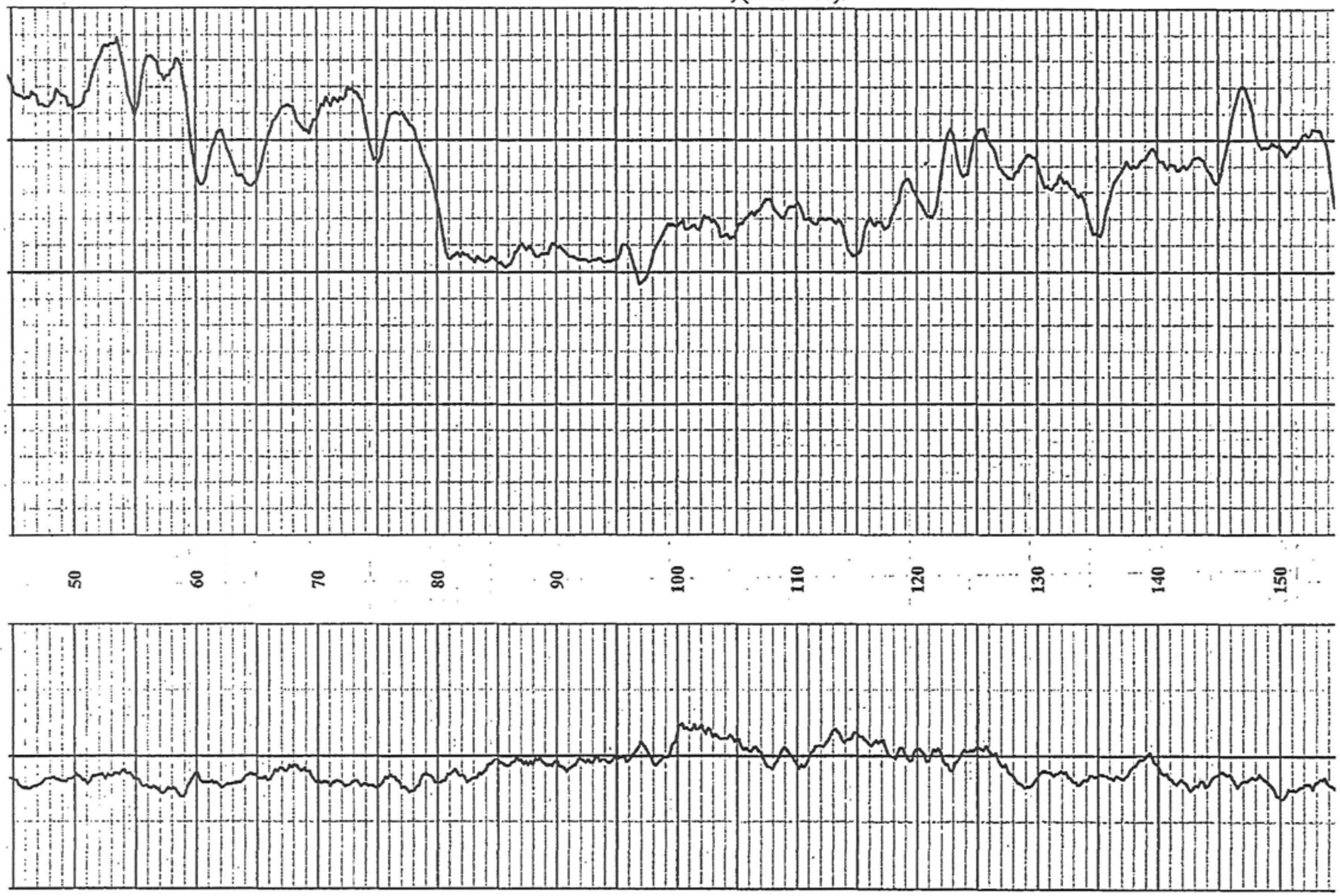
DATE	10-28-03	TYPE FLUID IN HOLE	FORMATION FLUID
RUN No	1	SALINITY	
TYPE LOG	GAMMA - NEUTRON	DENSITY	
DEPTH-DRILLER	260 FT	LEVEL	195 FT
DEPTH-LOGGER	260 FT	MAX. REC. TEMP.	
BTM LOGGED INTERVAL	260 FT		
TOP LOGGED INTERVAL	SURFACE		
OPERATING RIG TIME			
RECORDED BY	K. MITCHELL		
WITNESSED BY	FRED CRAFT		

RUN	BOREHOLE RECORD			CASING RECORD			
NO.	BIT	FROM	TO	SIZE	WGT.	FROM	TO
1	7 7/8"	SURFACE	160 FT	5"	PVC	SURFACE	160 FT
2	4 3/4"	160 FT	TOTAL DEPTH				



Revised Novem[illegible] '03

FIGURE 7-1D. NEUTRON AND GAMMA LOGS FOR WELL RM14, (continued).



Revised November 2003

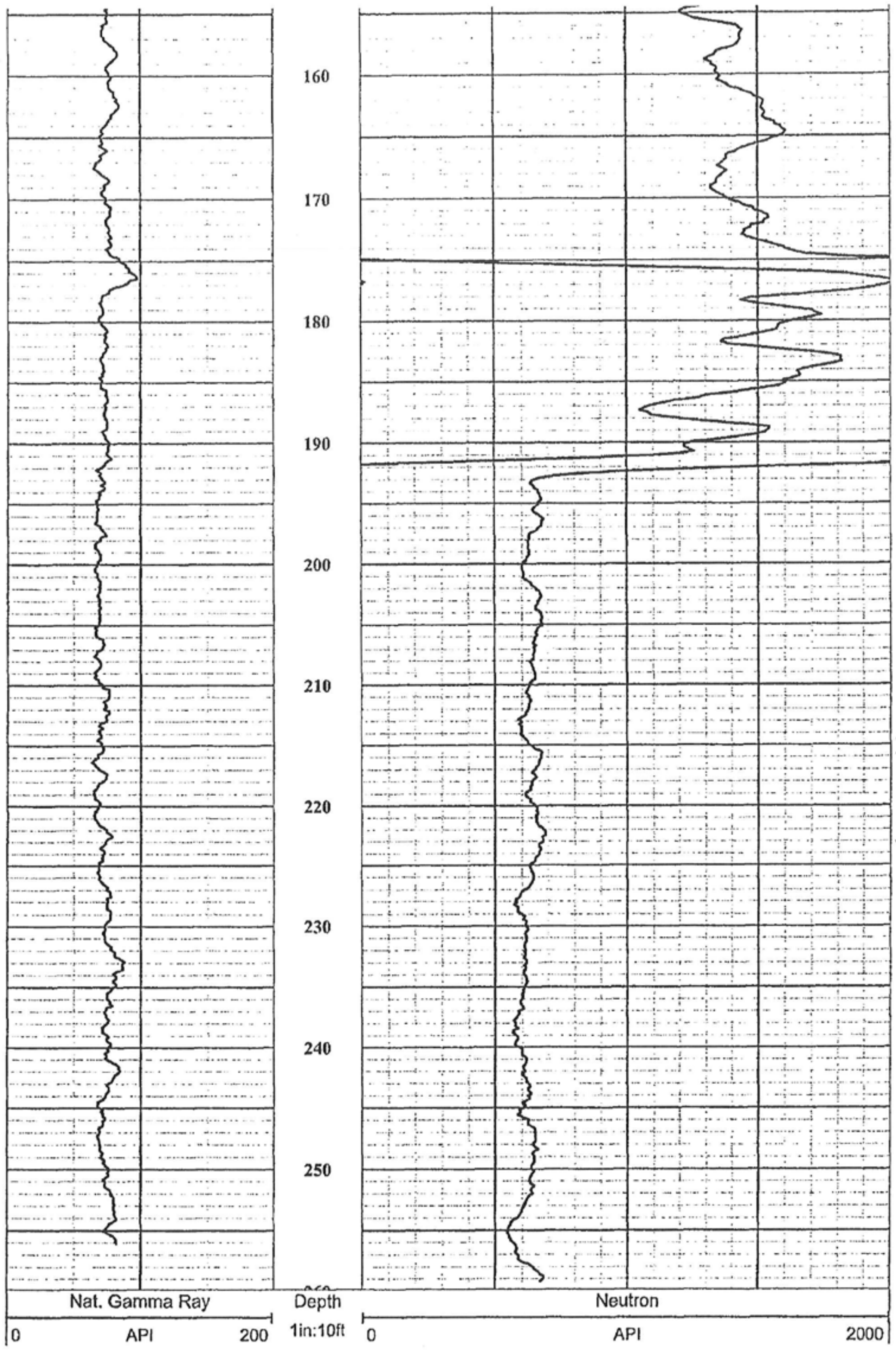


FIGURE 7-1D. NEUTRON AND GAMMA LOGS FOR WELL RM14, (continued).

Southwest Geophysical Services, Inc.

GEOPHYSICAL WELL LOG: NATURAL GAMMA RAY NEUTRON	**PERM. DATUM:** TOP OF CASING **LOG MEASURED FROM:** T. O. C. **ELEVATION:**	**OTHER SERVICES:**

COMPANY: PLATEAU RESOURCES
PROJECT/FIELD: TICABOO TAILINGS PILE
WELL: RM–8
LOCATION: SEC: T: R:
NORTH= **EAST=**
COUNTY: GARFIELD **STATE:** UTAH

ELEVATION KB:
DF:
GL:

COMPANY: PLATEAU RESOURCES
WELL: RM–8

	RUN NO. 1		RUN NO. 1
DATE	2/25/98	FLUID LEVEL	56 FT
DEPTH DRILLER	90 FT	FLUID NATURE	FORMATION FLUID
DEPTH LOGGER	78 FT	FLUID VISCOSITY	
BOTTOM LOGGED	77 FT	FL. RESISTIVITY	
TOP LOGGED INT.	SURFACE	FL. RES. @ B.H.T.	
CASING LEVEL	ALL	CIRCULATION TEMP.	
CASING SIZE	3 IN ID	BOT-HOLE TEMP.	
CASING SIZE	PVC	TOOL #	HS
BIT SIZE		LOGGED BY:	SHERRY MILLER
BIT SIZE		WITNESSED BY:	CHUCK JOHNSON

REMARKS:

THANK YOU

FIGURE 7-1E. NEUTRON AND GAMMA LOGS FOR WELL RM8.

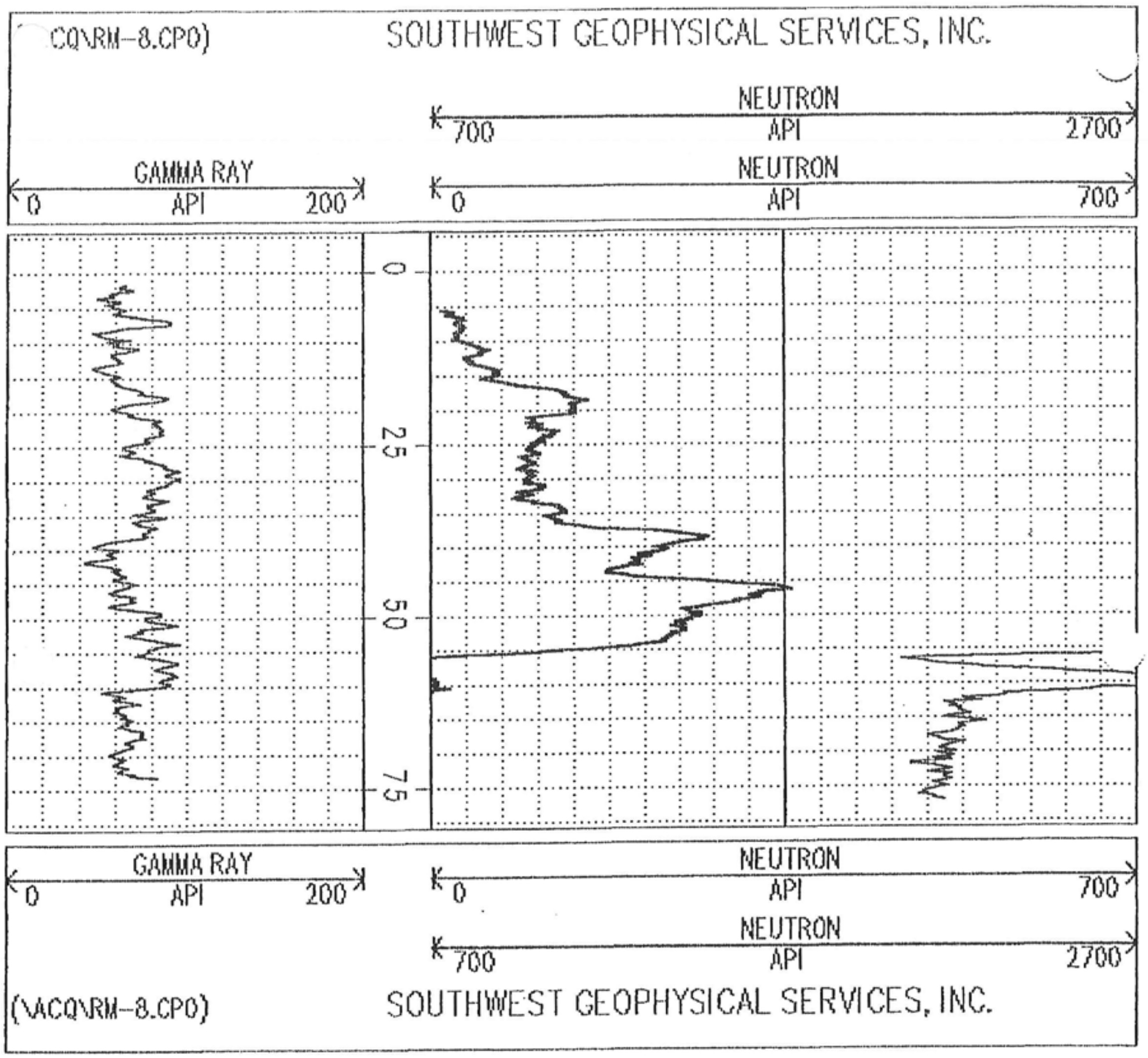
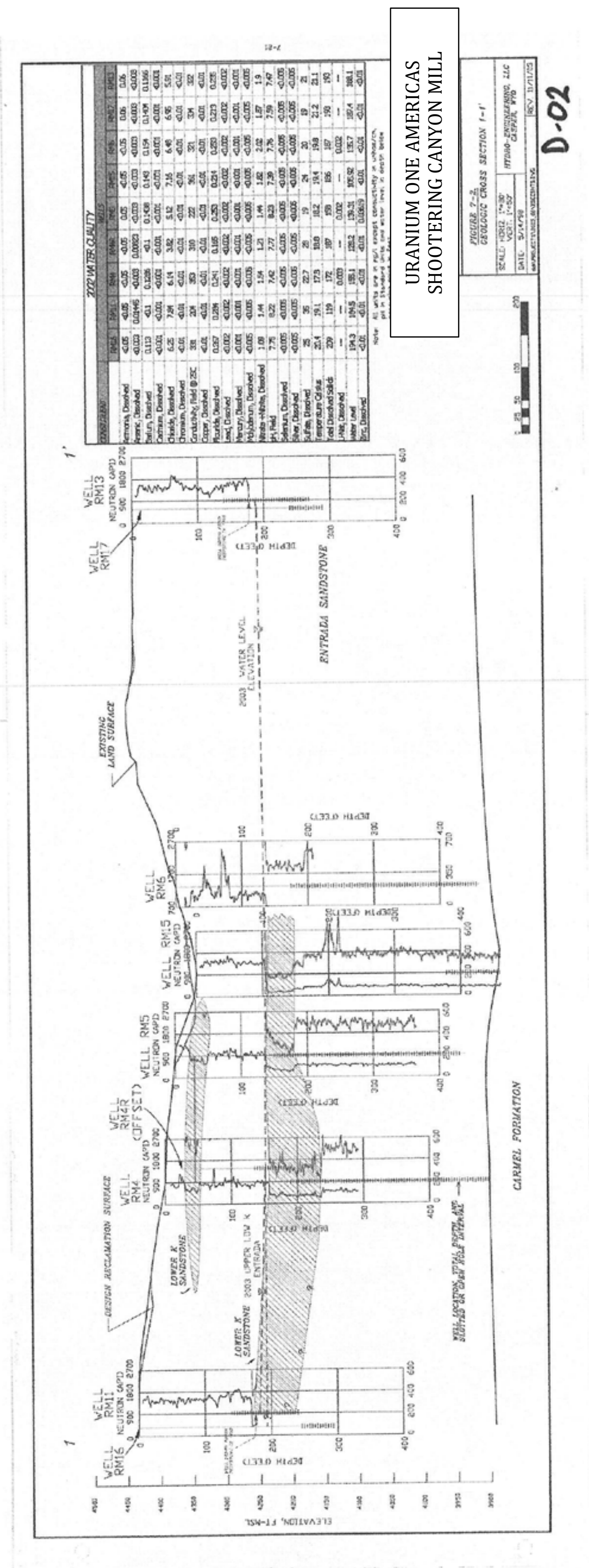


FIGURE 7-1E. NEUTRON AND GAMMA LOGS FOR WELL RM8, (continued).

7-20B Revised November 2003


URANIUM ONE AMERICAS
SHOOTERING CANYON MILL
D-02
WELL RM16
WELL RM11
WELL RM4
WELL RM4R (OFFSET)
WELL RM5
WELL RM15
WELL RM6
WELL RM17
WELL RM13
EXISTING LAND SURFACE
DESIGN RECLAMATION SURFACE
2003 WATER LEVEL ELEVATION
ENTRADA SANDSTONE
CARMEL FORMATION
LOWER K SANDSTONE
ELEVATION, FT-MSL
DEPTH (FEET)
NEUTRON (API)
2002 WATER QUALITY
FIGURE 2-2
GEOLOGIC CROSS SECTION 1-1'
HYDRO-ENGINEERING, LLC
CASPER, WYO

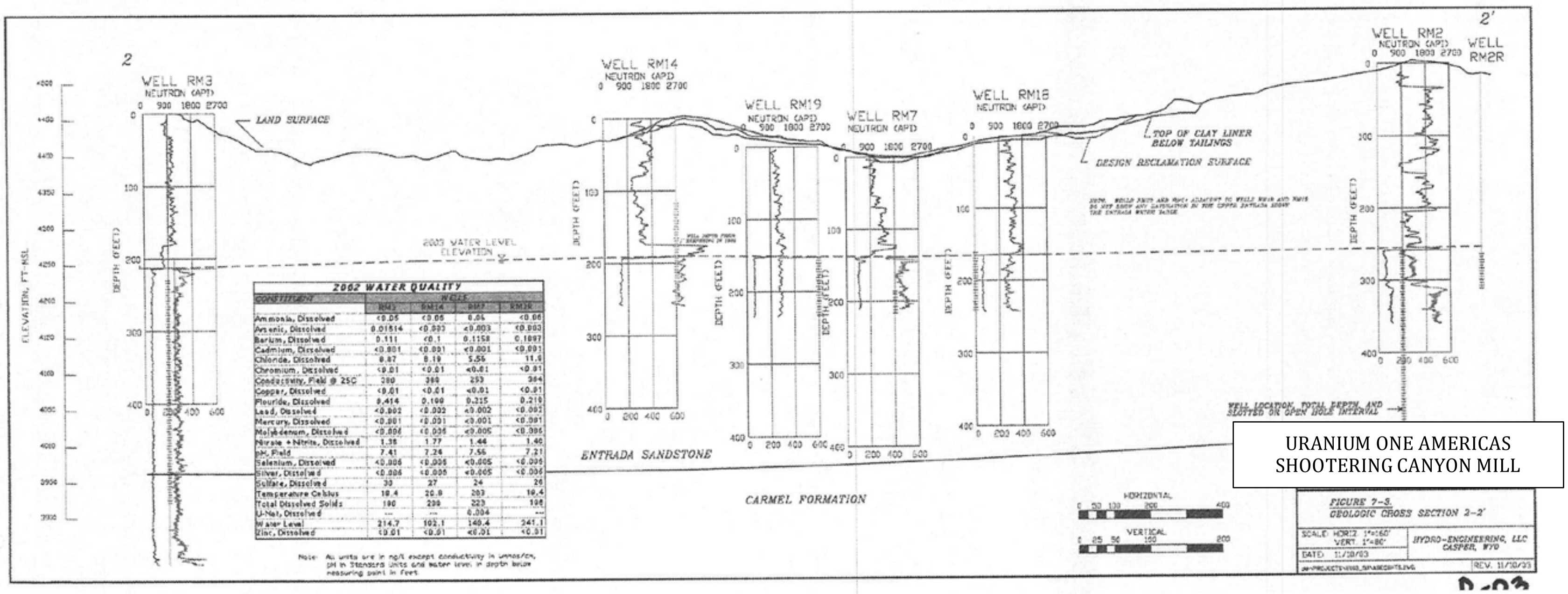
THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

FIGURE 7-2
"PLATEAU RESOURCES, LTD.
SHOOTARING CANYON MILL"
REV. 11/11/03

WITHIN THIS PACKAGE..

D-02



2002 WATER QUALITY

CONSTITUENT	WELLS RM3	RM14	RM7	RM2R
Ammonia, Dissolved	<0.05	<0.05	0.06	<0.06
Arsenic, Dissolved	0.01514	<0.003	<0.003	<0.003
Barium, Dissolved	0.111	<0.1	0.1158	0.1097
Cadmium, Dissolved	<0.001	<0.001	<0.001	<0.001
Chloride, Dissolved	8.87	8.19	5.56	11.6
Chromium, Dissolved	<0.01	<0.01	<0.01	<0.01
Conductivity, Field @ 25C	380	380	253	384
Copper, Dissolved	<0.01	<0.01	<0.01	<0.01
Flouride, Dissolved	0.414	0.190	0.215	0.219
Lead, Dissolved	<0.002	<0.002	<0.002	<0.002
Mercury, Dissolved	<0.001	<0.001	<0.001	<0.001
Molybdenum, Dissolved	<0.006	<0.006	<0.005	<0.006
Nitrate + Nitrite, Dissolved	1.38	1.77	1.44	1.40
pH, Field	7.41	7.24	7.56	7.21
Selenium, Dissolved	<0.006	<0.005	<0.005	<0.006
Silver, Dissolved	<0.006	<0.005	<0.005	<0.006
Sulfate, Dissolved	30	27	24	26
Temperature Celsius	18.4	20.8	203	18.4
Total Dissolved Solids	190	200	223	198
U-Nat, Dissolved	---	---	0.004	---
Water Level	214.7	102.1	140.4	241.1
Zinc, Dissolved	<0.01	<0.01	<0.01	<0.01

Note: All units are in mg/l except conductivity in umhos/cm, pH in Standard Units and water level in depth below measuring point in feet.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

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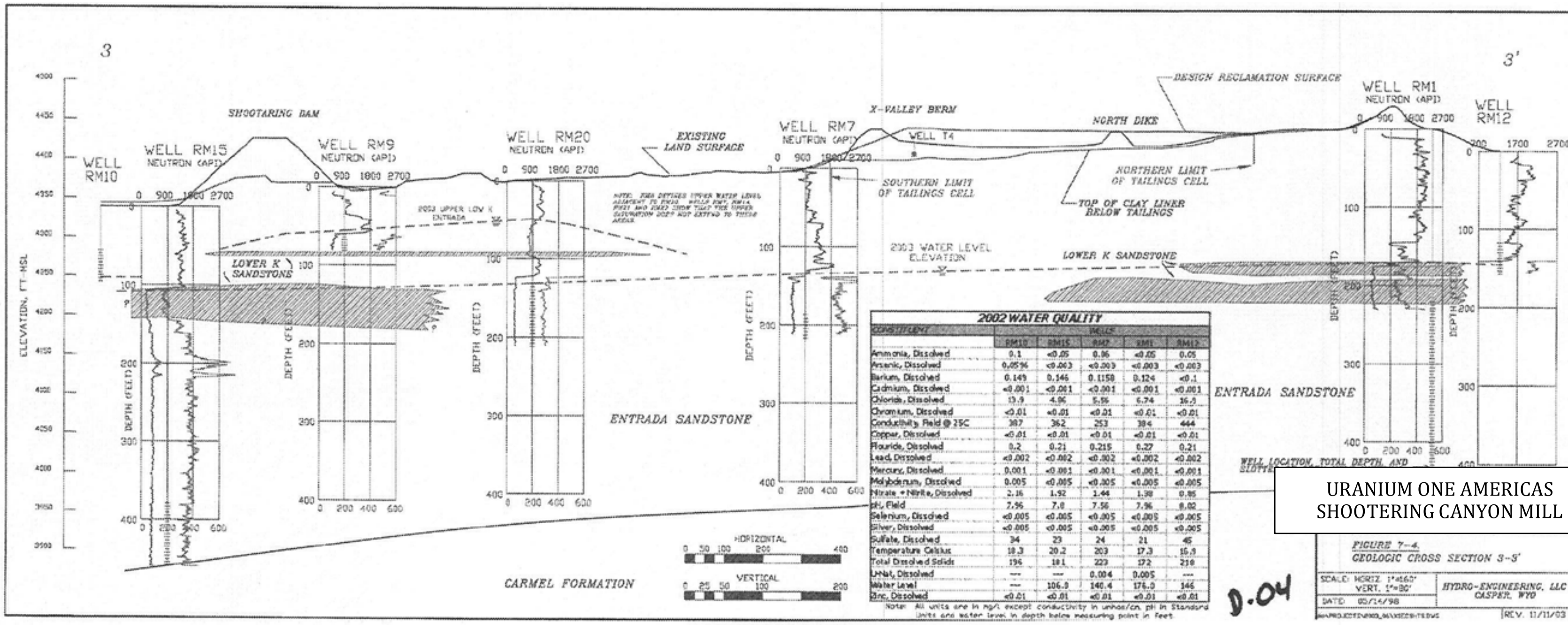
FIGURE 7-3
"PLATEAU RESOURCES, LTD.
SHOOTARING CANYON MILL"
REV. 11/10/03

WITHIN THIS PACKAGE..

D-03



2002 WATER QUALITY

CONSTITUENT	WELLS				
	RM10	RM15	RM7	RM1	RM12
Ammonia, Dissolved	0.1	<0.05	0.06	<0.05	0.05
Arsenic, Dissolved	0.0596	<0.003	<0.003	<0.003	<0.003
Barium, Dissolved	0.149	0.146	0.1158	0.124	<0.1
Cadmium, Dissolved	<0.001	<0.001	<0.001	<0.001	<0.001
Chloride, Dissolved	13.9	4.96	5.56	6.74	16.5
Chromium, Dissolved	<0.01	<0.01	<0.01	<0.01	<0.01
Conductivity, Field @ 25C	387	362	253	384	444
Copper, Dissolved	<0.01	<0.01	<0.01	<0.01	<0.01
Flouride, Dissolved	0.2	0.21	0.215	0.27	0.21
Lead, Dissolved	<0.002	<0.002	<0.002	<0.002	<0.002
Mercury, Dissolved	0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, Dissolved	0.005	<0.005	<0.005	<0.005	<0.005
Nitrate + Nitrite, Dissolved	2.16	1.92	1.44	1.38	0.85
pH, Field	7.96	7.0	7.56	7.96	8.02
Selenium, Dissolved	<0.005	<0.005	<0.005	<0.005	<0.005
Silver, Dissolved	<0.005	<0.005	<0.005	<0.005	<0.005
Sulfate, Dissolved	34	23	24	21	45
Temperature Celsius	18.3	20.2	203	17.3	16.9
Total Dissolved Solids	196	181	223	172	219
U-Nat, Dissolved	---	---	0.004	0.005	---
Water Level	---	106.9	140.4	176.0	146
Zinc, Dissolved	<0.01	<0.01	<0.01	<0.01	<0.01

Note: All units are in mg/l except conductivity in umhos/cm, pH in Standard Units and water level in depth below measuring point in feet.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

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FIGURE 7-4
"PLATEAU RESOURCES, LTD.
SHOOTARING CANYON MILL"
REV. 11/11/03

WITHIN THIS PACKAGE..

D-04

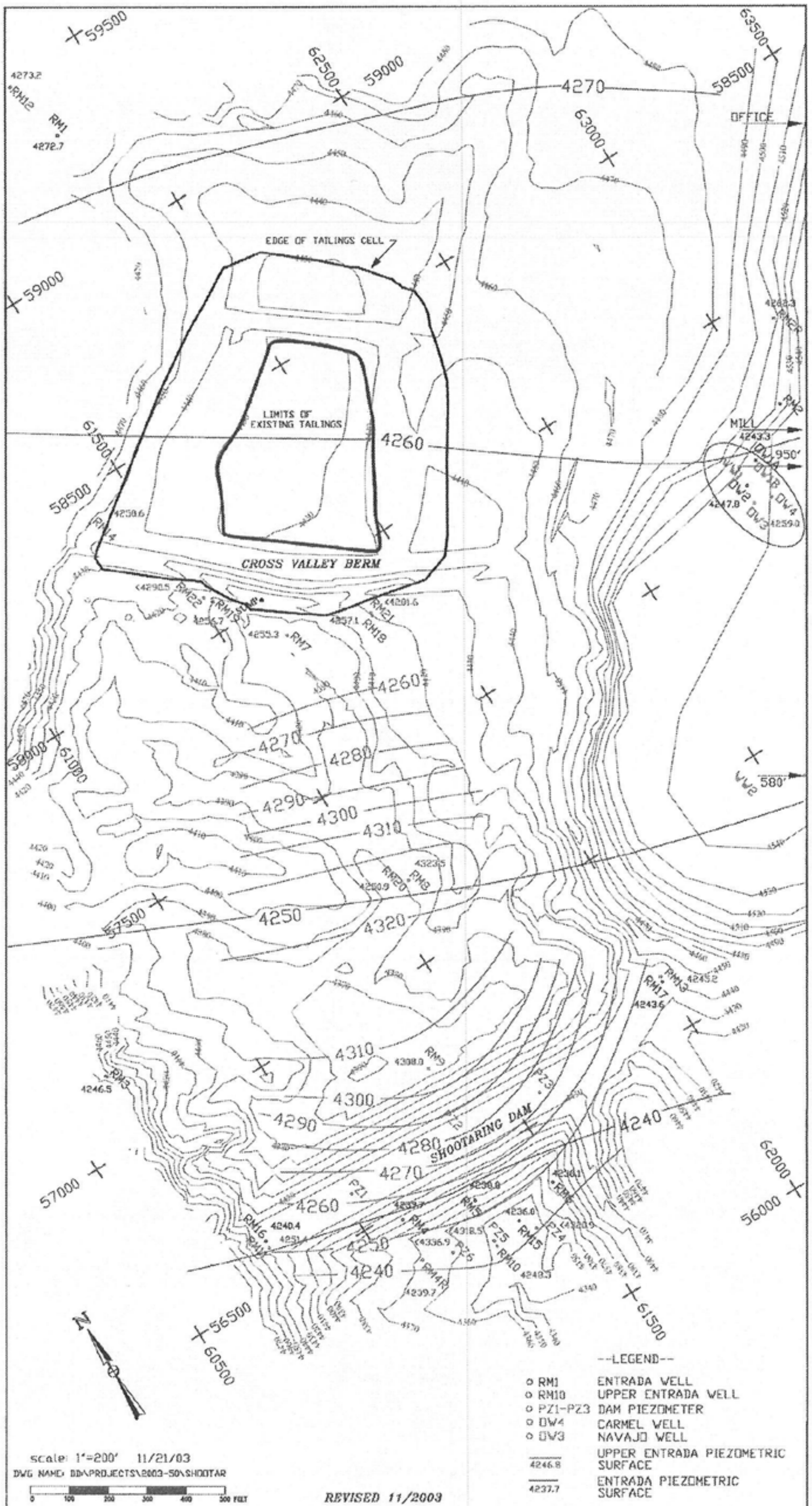


FIGURE 7-5. WATER-LEVEL ELEVATION IN THE UPPER ENTRADA AND ENTRADA AQUIFER, 2003, FT-MSL

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

FIGURE 7-5
"WATER-LEVEL ELEVATION IN THE UPPER ENTRADA AND ENTRADA
AQUIFER, 2003, FT-MSL"

WITHIN THIS PACKAGE..

D-05

8.0. MILL DECOMMISSIONING AND SITE CLEANUP

Uranium One Americas intends to decontaminate salvageable equipment for unrestricted release. Equipment and structures having no net salvageable value will be removed and placed in the tailings cell. Contaminated soils, ore from the ore stockpile area, and contaminated residues will be consolidated with the tailings and stabilized. Disturbed areas will then be graded and seeded for growth of native vegetation.

The mill site consists of the following:

Main Office Building	Truck Scales	Maintenance Shop
Ore Storage Area	Bucking Room	Warehouse
Grizzly - Dump Pocket	Acid Tank	Environmental Lab
Fuel Oil Tank	Potable Water Tank	Analytical Lab-Stacks
Raw Water Tank	Wet Scrubber- Stack	Reagent Storage
Conveyor- Tunnel	Seal Water Tank	Generator Buildings- Stack
Pump House	De-Mister Stack	
Grinding Leach Area	Solvent Extraction Area	
Cow1ter Current Decantation Area		
Precipitation - Drying - Packaging Area - Stack		

Plans for contaminated soil removal and decontamination or demolition of the structures are presented in the following sections.

8.1 Regulatory Requirements

All decommissioning activities will be done in accordance with the applicable requirements in Title 10 of the Code of Federal Requirements, the current license, and other applicable regulatory requirements. The work will be done as soon as practical in conformance with lOCFR 40.42(g).

The performance-based NRC license requires reviews of all operations and procedures to assure that radiation exposure to workers and the public will be maintained as low as reasonably achievable. At this time, it is believed that only one activity, the decommissioning of the yellowcake building, has the potential to result in exposures exceeding that from normal mill operations. Engineering controls, including the application of a fixative agent to control the release of uranium, will be reviewed and approved by the Safety and Environmental Review Panel (SERP). In addition to special engineering and administrative controls, standard management controls will govern the decommissioning activities, including the use of Standard Operating Procedures, Radiation Work Permits, and other administrative and engineering controls utilized by the Environmental and Radiological Health Supervisor (ERHS), site management Safety and Environmental Review Panel (SERP), and corporate management. Worker exposure concentrations will be measured utilizing one or more of the following methods: Bioassay, TLD and/or air sampling as conditions warrant.

Uranium One Americas will conform to the recordkeeping requirements in 10 CPR 40.36(f), where all records related to the decommissioning will be maintained for review and transfer to the government. This includes current records related to spills or releases and any known buried material or material out-sides of the radiation control area. Records will be kept at the Corporation main offices at 907 North Poplar Street, Suite 260, Casper, Wyoming 82601.

The environmental and occupational safety impact of decommissioning the mill will be minimal with the controls that have been outlined in the cleanup. See Appendix I for a list of Titles of Standard Operating Procedures that are in place and will be utilized and/or updated or modified as needed during the site reclamation and decommissioning. Standard Operating Procedures have been added, updated or modified to reflect the requirements of the reclamation plan. See Section 3.3 for additional discussion on Radiation health and safety. The consolidation of the contaminated soil and materials and placement in the capped tailings cell will eliminate this as a potential source of release to the environment. Impacts to plants and animals should be negligible due to the small surface area of disturbance and a relatively short reclamation schedule. The impact to the water quality will be positive in that all contaminated materials will be placed into a designed long-term disposal cell, making it less available for transport to surface and groundwater. Negative impacts include increased water use for dust control and soil conditioning and short-term degradation of the air quality during reclamation.

8.2 Disassemble and Dispose of Contaminated Equipment and Structural Materials

All materials and plant equipment unsuitable for unrestricted release will be placed in the tailings impoundment for disposal. This includes contaminated residues from tanks or vessels identified for decontamination to release criteria levels.

Table 8-1 lists the equipment anticipated for disposal. This equipment will not be decontaminated. Non-degradable material will be placed into a tailings pit and flowable fill added to fill the voids. The flowable fill to be utilized in reducing voids in and around mill demolition material placed into the tailings cell is designed to reduce voids only and not provide support or have strength after drying. The flowable fill is made up of cement, fly ash (class F or C), water and onsite soil material. The ratio of the mixture will depend upon type of soil, water and fly ash available. The mixture will be mixed onsite and poured into the demolition eel] to the top of the debris. The wood or other degradable material will be placed in single lifts no greater than 6-inches thick and covered with sandy fill material. A limited number of small items, such as the sump pump, will be buried with compacted fill prior to the placement of the cap. Pipe will be cut into manageable lengths and placed in the disposal pit to be filled with flowable fill. A minimum of three debris disposal pits are planned on top of the existing tailings.

TABLE 8-1. List of Equipment Anticipated for Disposal into Tailings Facility

Equipment	Construction Material
Ore grizzly Wet	Steel
Scrubber Sulfuric	Steel
acid tank	Steel
Leach feed tanks w agitator	Wood
Leach 1st stage w agitator	Wood
Leach 2nd stage w agitator	Wood
Primary thickener 1st stage	Rubber coated steel
Clarifier thickener 2nd stage	Rubber coated steel
Sand filters	Steel
Counter current decantation concrete pad	Concrete
Reagent mix tanks	Steel
Sodium chlorate tank	Steel
Solvent extraction tanks, mixers	Fiberglass
Solvent extraction scrubber	Fiberglass
Precipitation solution tank	Fiberglass
Yellow Cake precipitation tanks	Rubber coated steel
Yellow Cake thickener	Rubber coated steel
Yellow Cake drum filters	Steel
Yellow Cake calciner Yellow	Masonry & steel
Cake impact crusher Yellow	Steel Steel
Cake Scrubber Tailings	HDPEpipe
slurry line	Steel, fiberglass
Dust/fume collector	Steel, rubber coated steel,
Pumps, piping, electric motors and other misc.	fiberglass, copper
	Concrete, steel
Misc. concrete and rebar	Steel, fiberglas
Contaminated yard area	

8.3 Decontamination of Tools, Equipment and Buildings for Unconditional Use

All tools, equipment, and structures considered for unrestricted release will be decontaminated prior to monitoring. This includes all building surfaces classified as MARSSIM Class 1 and Class 2 (as defined in Appendix H). Decontamination methods include a combination of washing, high-pressure sprays, or steam cleaning. No hazardous waste constituents will be used in the decontamination process. The surfaces will be air dried prior to radiological monitoring.

Table 8-2 is a list of equipment and buildings that are anticipated to be cleaned and released. Any of the equipment and buildings on this list may be moved to the disposal list if cleanup efforts are not beneficial or the cost of cleanup exceeds the salvage value.

TABLE 8-2. List of Equipment/Buildings Anticipated for Unrestricted Release

Equipment	Size	Construction Materials
Office building	25'x80'	metal frame with metal siding, wood and gypsum board interior
Desks, file chairs		
Guard station		wood frame with wood siding and gypsum board
Scale		
Sample preparation building		steel
Ore Hopper		steel
Conveyor apron feed		steel
Conveyor structure		steel
Belt		rubber composite
Fresh water tanks -2 tanks		steel
Pump/fire house building	20'x50'	concrete, steel frame and steel siding
Temporary gensets		
Powerhouse building	60'x90'	steel frame and steel siding
3-gensets complete		
2-air compressors		
Control panels		
Dry (change rooms)		
Diesel fuel tank		steel
Electric switchgear		
Transformers		
SAG mill		
Controls		
Screens		
Mill control room instrumentation		
Mill office area		wood/sheet rock
Counter current decantation tanks		rubber lined steel
Ammonia tank		steel
Unloading pump		
Kerosene tank		steel
Pumping system		
Laboratory building	45'x85'	metal frame with metal siding, wood and gypsum board interior
Lab equipment		
Maintenance shop building	75'xl20'	steel frame and steel siding
Equipment		
Warehouse building	70'x75'	metal frame with metal siding, wood and gypsum board interior
Main mill building		steel frame and steel siding
Solvent extraction	70'xl00'	
Precipitation	40'x70'	
Reagent	40'x70'	
Grinding and leach	70'120'	

8.3.1 Monitoring and Release of Tools, Equipment and Buildings

Tools and equipment with potential radiological contamination will be monitored prior to release using existing standard operating procedures. Tools and equipment meeting the criteria in NRC guidance document "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use of Termination of Licenses for Byproduct, Source, or Special Nuclear Material, dated May 1987" will be released for unrestricted use.

Release criteria have been developed for building surfaces following NRC Regulation in 10 CFR 40, Appendix A and 10 CFR 20. The code, RESRAD-Build, was used to calculate the total effective dose equivalent (TEDE) to future occupants of the buildings when exposed to surface contamination from yellowcake and process liquids. It was assumed that the buildings will be used for industrial purposes and that workers occupying the buildings are the critical group. Appendix G presents the results of the TEDE modeling where a gross alpha contamination limit of 700 dpm/100 cm^2 is proposed. This limit conforms to the 10 CFR 20 TEDE limit of 25 mrem/y. The NRC requires the use of the Benchmark Approach for uranium recovery facilities, where the TEDE was calculated in Appendix E to be 34 mrem/y. This would have allowed approximately 950 dpm total alpha contamination levels. Because of ALARA considerations, the 700 dpm/100 cm^2 limit will be used.

The dose modeling presented in Appendix G showed that the dose from yellowcake was very similar to the dose from process liquids, if normalized to the gross alpha emission rate. Therefore a gross alpha contamination limit of 700 dpml 100 cm^2 will be applied to all buildings surfaces. The removable limit was established as 20 percent of the total limit, based on existing mill building surface contamination levels for total and removable.

A MARSSIM-based characterization and verification plan was developed and presented in Appendix H. This plan will be followed to demonstrate compliance with the surface contamination limits for building surfaces. Buildings will be monitored and released according to the monitoring procedures and release criteria presented in Appendices G and H. Areas within buildings showing evidence of possible penetration of process solutions will be evaluated for possible subsurface contamination. Based upon exposure of the building or area of the building to process solution that could be carried below the concrete floor, coring will be conducted in the SX, grinding, leaching and yellowcake sump areas. The cored concrete will be tested for process contamination (i.e. retained uranium and Ra-226) and the soil beneath the concrete should be tested in fifteen (15) centimeter intervals to determine if it has been contaminated. If the buildings, slabs and soils beneath the slabs are not contaminated, the buildings shall be released for unrestricted use, provided the building surfaces meet the release criteria and radiological monitoring requirements in Appendices G and H, respectively. Otherwise, the buildings will be demolished, the slabs removed, and the underlying soils removed (if contaminated) and all contaminated materials shall be placed in the tailings impoundment. Releasable concrete slabs may be covered with two (2) feet of clean native borrow soils in lieu of removal and disposal in the impoundment area.

8.3.2 Disposal of Non-radiological or Laboratory Chemicals

All reagents and laboratory chemicals remaining on site will be disposed of in conformance with all applicable federal and state regulations pertaining to the transport and disposal of hazardous material, where applicable. Potentially contaminated reagents and chemicals will be tested for byproduct contamination before transfer. Laboratory chemicals that did not come in contact with the uranium recovery process, and are not contaminated with radionuclides, will be transferred off site.

Two non-radiological hazards on the site are sodium chlorate and sulfuric acid. These hazards will be encountered during the decommissioning of the sodium chlorate and sulfuric acid storage tanks and distribution lines. Uranium One Americas has identified an outside consultant with experience in handling these two chemicals under uranium mill site conditions and Uranium One Americas will utilize his services.

8.3.3 Disposal of Decontamination Wash Water

The facility slabs are constructed to allow drainage of liquids to a sump. All decontamination water will drain to these sumps. Decontamination water will be disposed of in the tailings cell. This water will be used for dust and moisture control for the tailings reclamation and also used in the flowable fill mixing.

8.4 Contaminated Soil Cleanup

Section 3 presents the results of a recent radiological characterization survey that shows areas of the site where soil contamination exists. The survey shows that soil contamination is limited to areas of known spills and the ore storage area. The exact boundaries of the areas cannot be defined at this time since most of the areas were influence by gamma shine from nearby building components, ore piles, or tailings. The affected areas will be remediated using more sensitive survey equipment to assure compliance with the cleanup criteria. In order to assure that the extent of the area has been defined, a 10-meter buffer area (considered Class II and Class III in MARSSIM terminology) contiguous to each contaminated area will be evaluated for potential contamination. The buffer zone for the ore storage area will be 20-meters wide. The site cleanup criteria and procedures are presented in the following subsections.

8.4.1 Cleanup Limits for Soils

The contaminants on the site have been determined to be uranium ore, process solution residuals, Th-230, and to a lesser extent, uranium tailings. No evaporation ponds exist at this site except for the very small lined pit on the tailings where the cross valley berm sump water is pumped. This lined pit is normally dry. The cleanup criteria for tailings is given in 10 CPR 20, Appendix A. The criteria require the cleanup of Ra-226 to 5 pCi/g above background, averaged over the surface 15-cm depth layer and an area of 100 m^2. The limit for subsurface layers is 15 pCi/g.

For radionuclide mixes that are different than uranium tailings, the cleanup criteria are to be based on the Benchmark Approach, where the site-specific TEDE (Benchmark Dose) to the critical receptor is calculated using Ra-226 at 5 pCi/g in surface soils. The site-specific contaminant levels are then adjusted so that the TEDE does not exceed the Benchmark Dose.

The radionuclide mix of process solution residuals and uranium ore are identical, based on process knowledge. Therefore the Benchmark Approach was used to develop the cleanup criteria using a radionuclide mix of U-238 and U-235 with the progeny in secular equilibrium and assuming the natural abundance ratios for the uranium isotopes. The analysis, presented in Appendix E, limits the natural uranium contamination in soil to 9.1 pCi/g (13.4 mg/kg). This corresponds to a Ra-226 concentration of 4.4 pCi/g above background. For subsurface layers, it is assumed that the Ra-226 concentration limit would be 3 times the surface layer (similar to that of tailings), or 13 pCi/g above background levels. ALARA considerations require that an effort be made to reduce these concentrations to as low as reasonably achievable levels.

The area shown as "'F" in Figure 3-3A consists of approximately 6.5 acres and is potentially contaminated by Th-230 from a tailings water spill. Because the contaminants were originally deposited within the pool of fugitive solution, the distribution of Th-230 at the time of the spill was likely fairly uniform within the pool area. Some cleanup of the 6.5 acres affected by the fluid had been done shortly after the spill, and there is currently less than one acre exhibiting elevated surface gamma-ray exposure rates, attributable to Ra-226 contamination. The measured Ra-226 and Th-230 concentrations in soil samples taken from this small area were less than 35 and 200 pCi/g, respectively. The field gross alpha method will be applied to areas previously determined to be free of gamma-emitting radionuclides. Therefore alpha emissions above natural background levels should be attributable primarily to the decay of Th-230. Prior to applying the method at Shootaring, a set of data will be obtained using soil samples collected from the affected area and comparing the on-site Th-230 analyses to that of a vendor laboratory. This will result in site specific performance parameters (efficiency and MDA) for the gross alpha method. After reclamation, this area will be a sediment catch basin formed by the base of the Shootaring Darn. The darn will be cut to an elevation where sediment will be retained. The water dissipates by evaporation and seepage into the vadose zone. Over time, several feet of sediment will collect above Area F. Because of the undesirability of this area as a building or camping site, no people are likely to spend time there. This situation therefore does not lend itself to developing cleanup criteria using the Benchmark Approach since even short-time occupation of the area is unlikely since it is in the flood plain.

Since cleanup criteria for Th-230 contaminated soils do not exist, the Benchmark approach and an alternative calculation comparing Rn-222 releases were considered for establishing the cleanup criteria. The Benchmark method limits the residual radionuclide concentrations such that the dose is no larger than the dose from occupancy of the site if the surface soils were contaminated with Ra-226 at 5 pCi/g. The dose from radon emissions is specifically excluded. Several exposure scenarios for developing Th-230 cleanup criteria for this area were considered. For scenarios where short-term occupancy of the site is probable (camper, hunter, or hiker) the direct exposure as well as airborne particulate exposure to occupants would be very high if the surface soils were contaminated at 5 pCi/g Ra-226, compared to the exposures from Th-230 contamination lying beneath a 46-cm soil cover. Another exposure route considered was the use of water from an aquifer beneath the site as drinking water for nearby residents. However, it is widely known that Th-230 is immobile in near-neutral pH water. These exposure pathways lead to an unreasonably high Th-230 cleanup criterion. Thus the Benchmark dose assessment method was not applied at this site. The only significant exposure pathway from residual Th-230 results from Rn-222 releases from the in-growth of Ra-226. Since 10 CFR Part 40, Appendix A already has a standard for subsurface Ra-226, Uranium One Americas proposes to limit the existing Th-230 concentrations in any 15-cm layer and 100- m^2 area to that which would result in a maximum of 15 pCi/g ofRa-226 above background at any time during the next 1,000 years. This proposed approach is an alternate calculation for meeting the existing Ra-226 standard.

A minimum of 46 cm (18 in.) thick clean soil cover will be applied to the entire area to limit airborne erosion from this area until covered by sediment. If only Th-230 exists as a contaminant, then an additional 42 pCi/g of Th-230 will result in 15 pCi/g of Ra-226 at the end of 1,000 years.

The current Th-230 concentrations are much higher than the Ra-226 concentrations and therefore the Bateman equations show that the maximum Ra-226 concentration will occur at the end of the 1,000-year period. Therefore, Uranium One Americas will limit the Ra-226 to 15 pCi/g above background, where the Ra-226 concentration is calculated by the equation

Ra-226 (pCilg) = 0.65 Ra-226E (pCilg) + 0.35 Th-230E (pCi/g)

where the subscript "E" indicates currently existing concentrations.

A statistical analysis of the preoperational natural background data is presented in Appendix F. Recommended mean background level for U-nat is of 0.51 pCi/g, for Th-230 is 0.54 pCi/g, and for Ra-226 is 0.34 pCilg.

8.4.2 Gamma Action Level

Gamma surveys will be used to guide the soil remediation efforts. The surveys will identify soil contamination that exceeds the cleanup criteria and will be used to guide the cleanup efforts. After cleanup, the surveys will be used, in conjunction with surface soil sample analyses, to verify cleanup to the site cleanup criteria. A gamma action level, defined as a gamma count-rate level corresponding to the soil cleanup criterion, is used in the interpretation of the data. Normally the action level is conservatively developed to allow only a five percent error rate of exceeding the cleanup criteria at the 95% confidence level.

Conditions are not suitable at this time to develop an action level since the ore storage area contains ore piles and the most of the areas potentially contaminated by process solutions are in gamma shine areas. Therefore an action level will be determined after most of the contaminated material has been removed. An action level will be established by developing a correlation between Ra-226 concentrations and gamma-ray count rate using the appropriate statistical approach to estimate the 95% confidence level. The action level will correspond to a gamma- ray count rate that conservatively predicts that the Ra-226 in soil may be above the cleanup criterion. One action level will be required for use where process materials or uranium ore is the principal contaminant. Another action level will be required for areas affected by uranium tailings. These action levels are expected to be similar but will be checked for accuracy during the excavation of material.

Twenty or more locations within the contaminated area will be chosen where the Ra-226 concentrations do not exceed 25 pCi/g. Measurements will be made in locations where the gamma-ray levels are uniform. A 2-inch by 2-inch NaI detector will be placed at the normal monitoring height above the point and a count-rate determination made. A 5-point composite soil sample will be taken within a 3-ft diameter area to represent the average concentration within the circular area. The detector height of 45 cm will be used since at this height, a majority of the above-background counts should arise from gamma-rays originating from the 3-ft diameter area. This method of determining the action level has been shown to be equivalent toaveraging the gamma count rate over a larger area (100 m^2) and performing a five point sampling of the grid blocks, (Pathfinder Mines Corporation, Site Cleanup and Verification Plan for the Shirley Basin Mill Site). Correlations developed using smaller areas are necessary when there are no large uniformly contaminated areas. The gamma-ray count rates per pCi/g in the soil are, however, theoretically slightly smaller, resulting in a more conservative gamma-ray action level. The gamma action level(s) will be developed as soon as practical and will be provided to the UDRC at that time. The data and correlation(s) will also be included in the Completion Report. A correlation between gamma count rate and Ra-226 activity will also be developed using the final verification sampling results for the grid blocks. This correlation should confirm that the gamma action level was appropriate and resulted in compliance with the cleanup criteria. The final sampling and this correlation will be done while excavation equipment is still available on site. Correlation and sampling data will be supplied to the regulator as soon as practicable. The final correlation will also be presented in the Completion Report.

8.4.3 Gamma Surveys for Characterization and Verification

Two methods are proposed for conducting site gamma surveys, the first is the use of the GPS-based radiological survey system and the second is the use of the equivalent conventional method using a Ludlum 2221 rate-meter/scaler and Model 44-10 detector. Since the methods differ only by data recording and management, there are no apparent differences in the accuracy of the results. The surveys are described and Uranium One Americas will decide which method to employ.

<u>Gamma Surveys and Mapping Using Global Positioning System</u>

The GPS-based radiological survey will be done using equivalent equipment to that used in the correlation studies. The gamma-mapping system consists of digital gamma-ray monitoring equipment coupled to a Ludlum Model 44-10, a 2-inch by 2-inch Nal(Tl) detector. The digitized radiological count rate data are recorded once every two seconds by transmission to a Trimble ProXR GPS receiver (or equivalent), which automatically tags the data with the coordinates at the time the data count rate is received. The ProXR, manufactured by Trimble Navigation, is state-of- the-art land surveying equipment, employing the use of satellite global positioning system (GPS) technology. The accuracy of the coordinates is better than one meter while collecting data. The data are collected in a data logger and later downloaded into a computer. The data are then loaded into the ArcView GIS or other software for mapping and developing isocontours.

A gamma survey will be done over the extent of the affected areas and buffer areas. Gamma count rate isocontour lines at the action level will be used to defme where remediation is required. After the remediation, the area will be resurveyed and the new data added to the database. This iterative procedure will be applied until all areas are determined to meet the action levels.

In the verification phase, the average count rate over each 100-m^2 grid block is calculated by downloading the data into a database management computer application. The data records within each grid block are counted, averaged, and assessed as to whether the grid block meets verification criteria.

Function checks for the equipment will be performed at the beginning of each work shift using standard operating procedures. In addition, standard operating procedures will be used for operating the GPS-based radiological survey equipment as well as processing the data.

Radiological Surveys and Mapping Using Conventional Methods
Gamma surveys may be conducted using the same type of radiological survey equipment described above, other than the data will be recorded manually and presented on maps with isocontours using computer assisted means. Grid blocks of 33-ft by 33-ft (approximately 100m^2) will be established over the affected area. In order to determine the average gamma count rate within a grid block, the Ludlum Model 2221/Model 44-10 combination will be used to integrate the count rate while a technician walks the area for one minute. Correlation studies at other mill sites have demonstrated that this results in a good correlation with the Ra-226 in the soil.

8.4.4 Excavation Control Monitoring

Remediation of contaminated soils will be done by excavation. The purpose of excavation control monitoring is to guide the removal of contaminated material to the point where it is highly probable that an area meets the cleanup criteria. Monitoring equipment and action levels developed in the calibration studies will be used for excavation control monitoring. A technician will monitor the soil after the removal of layers of soil until the instrumentation shows that the levels are below the action level. The detector is held close to the ground so that small "hot spots" will be identified and removed. This will lead to each grid block having a uniformly contaminated surface soil layer. This reduces sampling error and will provide additional assurance that the average measured concentration meets the cleanup criterion. No documentation of the results is done since the verification data will serve to demonstrate compliance with the cleanup standards. For large areas, a GPS based survey may be performed periodically to predict the progress of the excavation.

For areas exhibiting contamination below the top six inches, excavation control monitoring will be done using the same detector as used in the calibration study, considering the appropriate action level and adjusting for geometry factors. The cleanup limit for deep excavations in tailings affected areas where backfill is applied is 15 pCi/g above background for Ra-226. For ore or process material contaminated areas, the subsurface criterion for Ra-226 is 13.2 pCi/g (or 27.3 pCi/g U-nat) developed in the Benchmark Dose Assessment.

Excavation control for the Th-230 contaminated areas will be done using a gross alpha procedure. The soil sample will be dried and pulverized and placed in a ZnS-coated container. The container wll be counted in a Lucas Cell Counter. The counter will be calibrated using soil samples collected from the site and analyzed for Th-230 by a vendor laboratory using isotopic thorium procedure, EPA-970. The measured gross-alpha MDA for this procedure is 14 pCi/g. All soils with elevated uranium or radium concentrations will be removed by excavating soils with elevated gamma-ray emissions. Samples will be taken throughout the area and the sample locations determined by GPS. Additional soil will be removed from areas exceeding the cleanup criteria for Th-230. Standard Operating Procedure HP-24, Soil Screening Method for Th-230 in Soil, provides details for this method. Samples will be taken throughout the area based upon the concentration of Th-230 and physical spacing of the previous Th-230 sampling. Should the physical terrain change (i.e. from flat to sloping), the frequency of sampling will increase so as to predict the Th-230 activity more accurately.

8.4.5 Soil Cleanup Verification Survey and Sampling Plan

A final gamma survey of the affected area and buffer zone will be performed using the GPS-based equipment or conventional equipment as described above. For the GPS-based survey, a minimum of
10 data records in each 100-m^2 grid block will be used to obtain the average gamma count rate for the affected areas of the site. For conventional surveys, a 1-minute integrated count while walking the area will be used as the average count rate.

For all grid blocks where the average count rate (bare Ludlum 44-10 detector) exceeds the action level, the grid blocks will either be cleaned to below the action level or the grid blocks will be sampled to assure compliance with the cleanup criteria. The five-point soil sampling procedure is given in SOP HP-22. The sample will be analyzed to assure that the Ra-226 and uranium concentration complies with the cleanup criteria.

All verification samples will be analyzed by a vendor laboratory according to specified QA/QC procedures. Standard Operating Procedures HP-21, HP-22 AND HP-23 include details of the soil cleanup verification surveys and sampling plans for surface and subsurface contaminated areas.

For the Th-230 contaminated area (Area F), all areas exhibiting elevated gamma levels will be cleaned to near background levels. Soil samples will be taken from Area F and analyzed on-site or at a vendor laboratory until evidence shows that the area meets the 42 pCi/g above background Th-230 limit. Documentation of the sampling locations and the results will be included in the completion report. The area will then be divided into 100m^2 (33-ft by 33-ft) grid blocks. Thirty percent of the grid blocks will be randomly selected for sampling and analysis at the vendor laboratory for Ra-226 and Th-230. If all grid blocks do not meet the criterion, an additional 30 percent of the grid blocks will be sampled and the process repeated until the sampled set meets the cleanup criterion. The sampling method and quality assurance requirements specified in standard operating procedures, HP-21, HP-22, HP-23,.and HP-24 will be applied to this area. Uranium One Americas will submit field control and verification data for Area F to the regulator before Area F is covered.

8.4.6 Laboratory Quality Assurance

All verification samples will be sent to a Utah-certified laboratory for analysis for Ra-226. For 90 percent of the samples, the entire sample will be transported to the contract vendor laboratory. Ten percent of the samples will be selected at random and split, one part going to contract vendor laboratory and the other part to another vendor laboratory. The analytical methods that will be used for U-nat and Th-230 are EPA Method 6020 and EPA Method 907, respectively.

The results from the two vendor laboratories will be evaluated by assuring that the error bars overlap at the three standard deviation levels for all samples having measured Ra-226 concentrations greater than 1 pCi/g. That is, if the sample results for laboratories A and B are reported as $C_A \pm 3\sigma_A$ and $C_B \pm 3\sigma_B$, where σ is the standard deviation, Uranium One Americas will conduct an investigation if the following condition is not met: $[C_A - C_B] \leq [3\sigma_A + 3\sigma_B]$. The investigation may include having one or both laboratories repeat their analysis. The reason for not including the test for results less than 1 pCi/g is that the agreement at these low levels is normally not a good indicator of laboratory quality. For small values, the large relative errors almost always allow the above test to be met. It has been our experience that the above test is very difficult to pass for a large set of samples and therefore we may expect sample results that never agree even after the subsequent investigation and further analyses. We however should expect that no bias exists between the two sets of vendor lab data. The bias will be determined by performing a linear regression between the data pairs. Any bias should be less than the difference between the cleanup limit and the highest value measured in the set of verification samples. Other statistical tests may be performed such as those to identify data outliers prior to assessing the bias.

The widely differing results between laboratories can be explained by the fact that it is difficult to estimate the error for the analysis of a particular sample. It has been our experience that commercial laboratories report an underestimate of their errors, often indicating that the errors are the counting statistical errors only. They ignore the larger, often unknown, other statistical and systematic errors associated with the analysis. These include a systematic bias of up to five to ten percent due to errors in the calibration standards, errors associated with determining the chemical extraction yield for radiochemical analysis, and the potentially very large error associated with taking an aliquot from the larger sample. In order to assess these errors accurately, it would be necessary to perform analyses on several aliquots taken from the same large sample. This is costly and almost never done. We therefore, as indicated above, expect several samples to not meet the criterion for agreement even after the investigation has been completed. We believe that the overall QA program will, however, provide confidence that the analyses are acceptable and that the site meets the cleanup goals.

Should it be discovered that a bias exists between the two laboratories that would be expected to result in the failure of grid blocks using .the primary laboratory results, the failed grid blocks will either be further decontaminated and sampled or a third laboratory will be used in order to better understand the source of the bias.

Uranium One Americas management will check all aspects of data collection and input to verify that procedures are being followed. The collection and handling of samples from the mill decommissioning, soil cleanup, ore pad cleanup, Area F cleanup, and other radiological cleanup areas will be reviewed and approved by management. Laboratory results for these samples will be evaluated for completeness and consistency. Other aspects of the reclamation including adherence to the SOPs and adherence to the reclamation plan will be evaluated by Uranium One Americas management on a daily basis. The construction process will be monitored to confirm that appropriate physical and radiological safety procedures are followed. Excavation processes will be monitored to ensure that contaminated materials are not handled carelessly and that any spillage is collected and contained. The conveyance of contaminated materials to the tailings area will be monitored to prevent dispersal of these materials in the environment. Construction and sampling activities will be documented and reviewed throughout the reclamation process.

8.5 Land Restoration

After the mill site, ore stockpile, and Th-230 contaminated areas have been verified as meeting the cleanup criteria, a completion report will be prepared and submitted to the UDRC for approval. Upon approval, Uranium One Americas will grade the area to prevent excessive erosion and to blend the site with the natural topography, to the extent practical. Native site soils will be added where practical to help establish natural vegetation. Some areas will only be graded for commercial use while other areas having no commercial use will be seeded.

A mixture of 2 pounds each of rabbit brush, crested wheat, alkali solution, four wing salt brush, shad scale and Indian rice grass seed will be planted at a rate of 12 pounds per acre.

8.6 Quality Assurance and Quality Control

The Radiation Safety Officer is responsible for implementing the Quality Assurance and Quality Program *(QA/QC)*. He (or his designate) will periodically review the program. Items for review include the performance of the personnel, the adequacy and completeness of the records, and the maintenance of the radiological instrumentation.

The *QA/QC* for the radiological aspects of the decommissioning will be administered through use of trained and qualified personnel, adequate and maintained equipment, documented procedures, a good record keeping system, and internal checks and audits.

Radiation technicians will be qualified by the Radiation Safety Officer (or his designate) to perform specific quality tasks. Quality tasks are those tasks where the quality of the work is related to achieving the performance requirements of the project. This will be accomplished by requiring the technician to demonstrate an understanding of the equipment and SOPs for the task. A list of qualified technicians will be maintained for each quality task. Periodic reviews of each technician's performance will be made by the RSO (or his designate).

All monitoring equipment will have current calibrations. Functions checks will be done before and after daily use.

Chain-of-custody forms will be used for all verification soil samples, which will be analyzed by an off-site vendor laboratory. A fraction of these samples will be split and submitted to another vendor laboratory for analysis. The details of the Laboratory Quality Assurance program are given in Section 8.4.6.

9.0. TAlLINGS RECLAMATION

9.1 Description of Tailings Reclamation

Tailings reclamation will include the removal of approximately 2 to 3 feet of ore from the top of cross valley berm. The remainder of the upper portion of the cross valley berm is Entrada fine sand, which will be pushed into the tailings cell to fit the designed slopes. The clean-up of the soil contamination near the toe of the Shootaring dam will be done and placed in the tailings cell. The Mill demolition material will be placed in disposal pits within the cell and the voids will be filled with flowable fill. The ore stockpile will produce the largest amount of fill for the tailings cell and will be used to reach the pre-barrier contours. The reshaping of the cross valley berm and the north dike will also be completed while the ore stockpile material is placed in the tailings cell.

Figure 9-1 presents the present topography and reclamation cross-section locations for the tailings cell area. The base of the clay barrier, or pre-barrier, contours are presented in Figure 9-2. These are the contours that should be developed prior to placing the clay barrier. The elevation of the contours northwest of the outlet channel can be varied slightly upward or downward to account for the variations in actual volumes. The clay and red fine sand southeast of the east dike can be .used as an interim cover if needed to reach the pre-barrier contours.

The fill thickness to the base of the clay barrier (difference between green elevations on Figure 9-2 and existing land surface elevations on Figure 9-1) is presented on Figure 9-2A. The limit of existing tailings and the edge of the design tailings cell are shown on Figure 9-2A. The majority of the fill thickness in Figure 9-2A is made up of the ore. The radiological properties of the ore samples (sample prefix OP) are presented in Table 3-1. The existing tailings will typically be overlain by 12 feet to 16 feet of the fill material. There was very little slimes encountered in the tailings drilling (a 2.4 inch thick layer in backhoe pit T7, a 2.5 feet thick layer in test hole T5, and a 3.5 feet thick sand and slime layer in test hole T5) and the total thickness of fill and cover over the slimes will be in excess of 20 feet. Therefore, the tailings or slimes within the tailings do not contribute significantly to the radon flux with the design configuration.

The clay for the barrier cap will be obtained from the Shootaring dam and will be compacted on top of the pre-cap surface. The clay cap will be followed by two feet of the soil/rock mixture in zone 2 of the Shootaring dam. The soil/rock mixture will be followed by the rock protection layer. Figure 9-3 shows a schematic of the disposal cell cover system. Figure 9-4 shows a cross section through the center of the Shootaring dam. The zone 1 material is the source for the clay barrier while zone 2 material will be used for the cover soil material.

The design surface is presented in Figure 9-5. This surface shows the contours that should exist with the rock cover protection on the tailings cell. Six cross-sections, three from the northwest to the southeast and three from the southwest to the northeast, were developed to convey the layer sequence with respect to the reclamation cell. Figure 9-6 presents the reclamation cross- section A-A' (see Figures 9-1 and 9-5 for locations of the six cross-sections). These cross-sections present the design surface in magenta, the base of the cover system in red, and the present land surface in brown. The soil cover and clay that exists below the current land surface are also shown on the cross-sections. The location of drill sites, backhoe pits, and auger holes used to develop the thicknesses of the existing material are also shown on the cross-sections. Cross-section A-A' shows that up to approximately 13 feet of material will be placed on the north side of the north dike. This also indicates that this area contains a thin layer of contamination from tailings solution that existed in this area prior to the construction of the north dike. The use of this portion of the area north of the north dike within the cell prevents the required cleanup of this thin layer of contamination.

Figure 9-7 shows the reclamation cross-section B-B' which is through the middle of the tailings cell from the northwest to the southeast. This cross-section shows a thin layer of tailings that exists in the tailings cell which transitions into the ll.e(2) material that was deposited on the east dike. A significant amount of additional disposal will occur in this area of the tailings cell. The southeast side of this cross-section shows the outlet channel which will allow drainage from north of the north dike along the east side of the tailings cell to an outlet to the south of the cross valley berm.

Figure 9-8 shows the reclamation cross-section C-C' which is across the tailings cell to the northeast of the cross valley berm. This cross-section shows a thicker layer of tailings that is present in this area which also transitions to the ll.e(2) material to the southeast in the east dike area. The additional proposed disposal zone is shown in this cross-section. This cross-section also shows the thicknesses of the existing clay liner.

Cross-section D-D' which runs from the southwest to the northeast along the west side of the tailings cell is shown in Figure 9-9. This cross-section does not show any existing tailings because it is located to the northwest of the existing deposition. The ore that is present on top of the cross valley berm is shown in the cross-section along with the present soil cover above the existing clay barrier in this area.

Figure 9-10 presents cross-section E-E' which runs through the center of the tailings cell from the southwest to the northeast. A thickness of up to 18 feet of tailings (mill tailings, cleanup of solution spill and interim cover) is shown in this cross-section which also shows that the ll.e(2) material exists in the north dike.

Cross-section F-F' runs along the east dike and shows the cross valley berm and the ll.e(2) material that exists in the east dike to the northeast of the cross valley berm. This cross-section is along the edge near the southeastern limits of additional proposed disposal that shows up to three feet of additional disposal of material at this location. The edge of the tailings cell will be located just to the southeast of this cross-section where the clay cover will be tied into the existing clay liner.

9.2 Source of Fill

The sources of contaminated material for disposal in the tailings cell are the ore on top of the cross valley berm, the contamination at the toe of the Shootaring dam, mill decommissioning material, and the ore stockpile.

9.2.1 Ore on Top of the Cross Valley Berm

Approximately two feet of ore was placed on the cross valley berm for protection of erosion of the Entrada sand that was used to construct the berm. This ore will be removed and placed within the tailings cell. An estimate of 6700 cubic yards are planned to be excavated from the berm and placed in the cell.

9.2.2 Toe of the Shootaring Dam

The gamma survey defined an area upstream of the Shootaring dam that contains elevated radionuclide concentrations. This contaminated soil will be picked up and placed in the tailings cell. The lowermost portion of the rock protection on the tailings dam and the soil in the pool area contains the volume of contaminated soil. The rock will have to be removed and separated from the soil to be excavated and placed in the tailings cell. The volume of material to be placed in the tailings cell from the toe of the Shootaring dam is estimated to be 18,000 cubic yards.

9.2.3 Mill Decommissioning

Equipment from the mill decommissioning that is unsuitable for decontamination will be placed in the disposal cell. The equipment will be placed in pits in the tailings cell and then filled with a flowable fill to fill the voids. Wood boards will be placed in the cell with a thickness no greater than 6 inches and covered with sandy material.

9.2.4 Ore Stockpile

The ore stockpile volume is estimated at 65,500 cubic yards which includes the cleanup of one foot of material below the ore. This material will be placed in the tailings cell in a fashion to meet the pre-barrier cap contours. Adjustments for volumes larger or smaller than the quantities estimated will be made in the pre-cap contours by adjusting the elevation of the contours to the northwest of the outlet channel.

9.3 Barrier Cap

The barrier cap will consist of a compacted clay layer protected by a two foot layer of sand, silt and rock which will be obtained from zone 2 (rocky soil) in the Shootaring dam (see Figure 9-4) and a rock protection cover placed on the rocky soil layer. Figure 9-3 presents a detail of the disposal cell cover system. The clay cap layer will be 1.5 feet thick and require 37,000 cubic yards of clay borrow from the tailings dam. More than twice this volume exists in the Shootaring Dam. The zone 2 material for protection of the clay is estimated to be 52,000 cubic yards. The rock protection for above the zone 2 cover is estimated at a volume of 19,200 cubic yards.

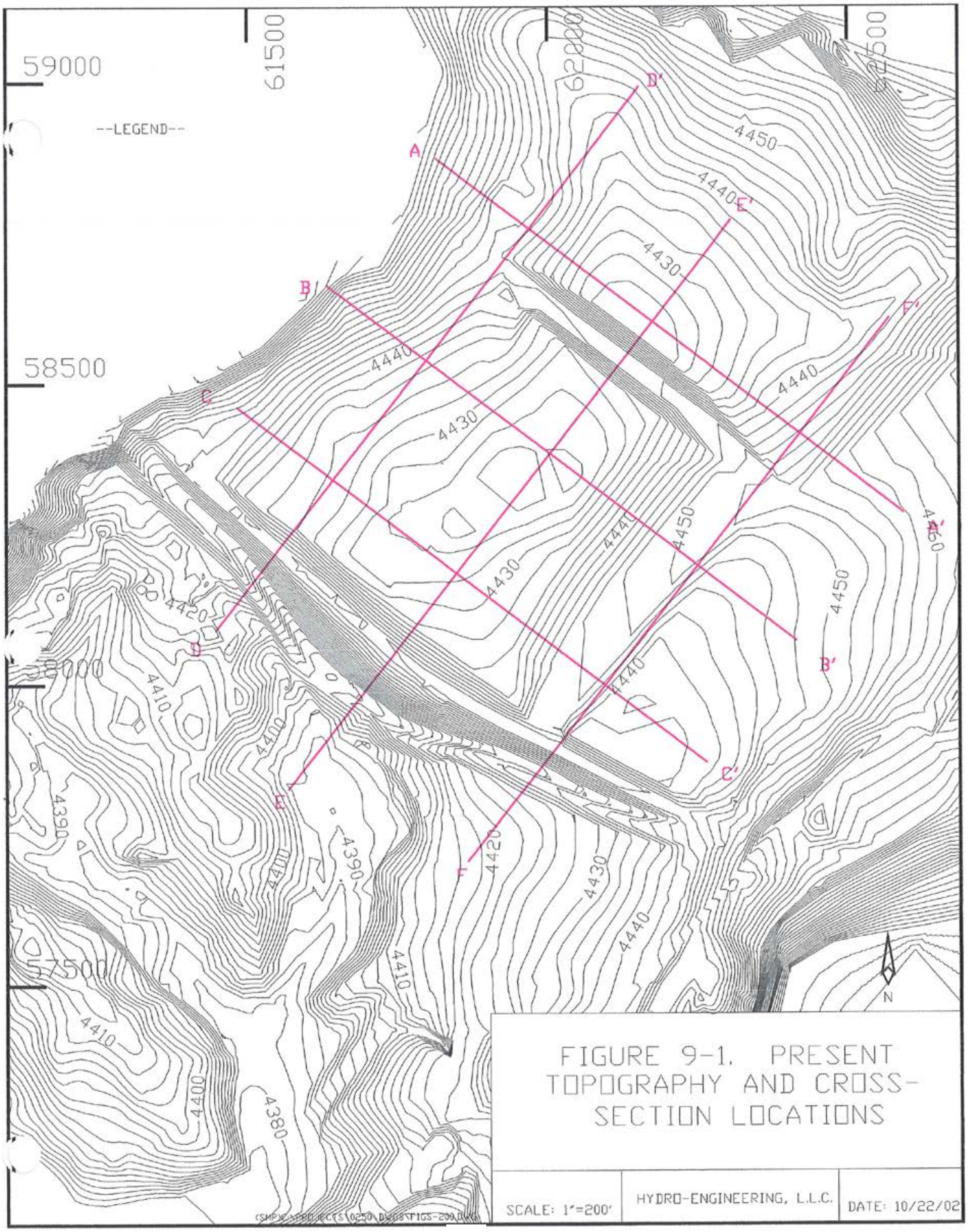
9.4 Disposal of Excess Clean Material

The borrow of clay and rocky soil from the Shootaring Dam and the creation of the dam breach will result in an excess of zone 1 (clay), zone 2 (rocky soil) and zone 3 (very fine sand). This material is proposed to be disposed of on the upstream side of the Shootaring Dam. Figure 9-14 shows an area where this material is proposed to be placed. The outlet through the Shootaring Dam cannot be blocked by this material and therefore a flow path for water to reach the outlet elevation through the dam will be required. A volume of 89,000 cubic yards is estimated for the excess clean material from the Shootaring Dam breach.

The channel cut on the east side of the tailings cell will also create a significant amount of excess material. This material is proposed to be deposited in the area to the southwest of the tailings cell. This area is also shown on Figure 9-14. A volume of 68,000 cubic yards of excess cut has been estimated for disposal in this area.

9.5 Environmental Impacts

The reclamation of the tailings will result in the encapsulation of the radioactive material, significantly decreasing the potential for radiation exposure at the site. Based on our analysis, the erosion protection system will protect the encapsulated material for at least 1000 years and thereby decrease the potential for future exposure. The cap also should decrease infiltration to such a low level that no potential future impacts to the ground water should occur. Erosion protection and the cover system should also prevent any exposure of the cell material to surface water.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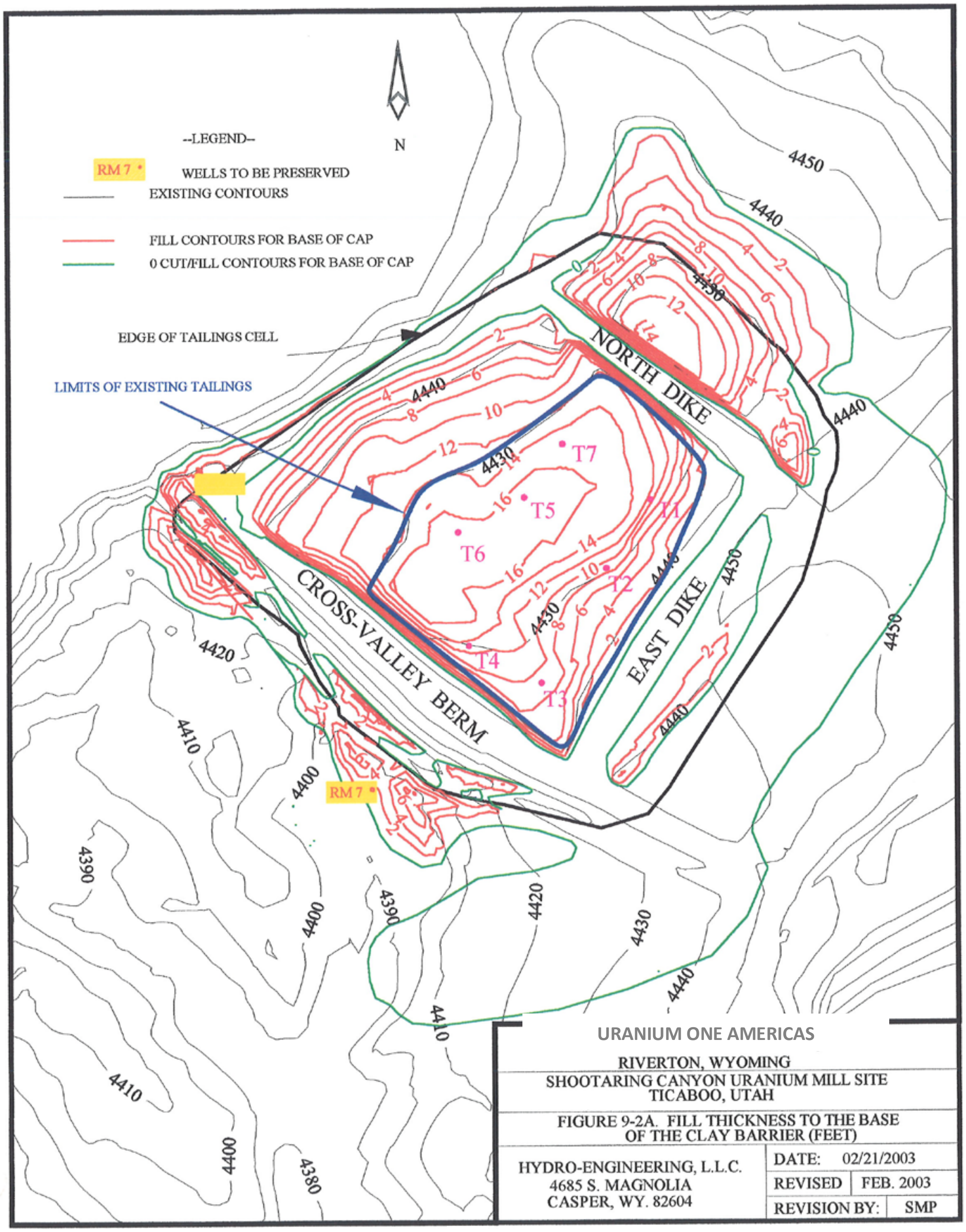
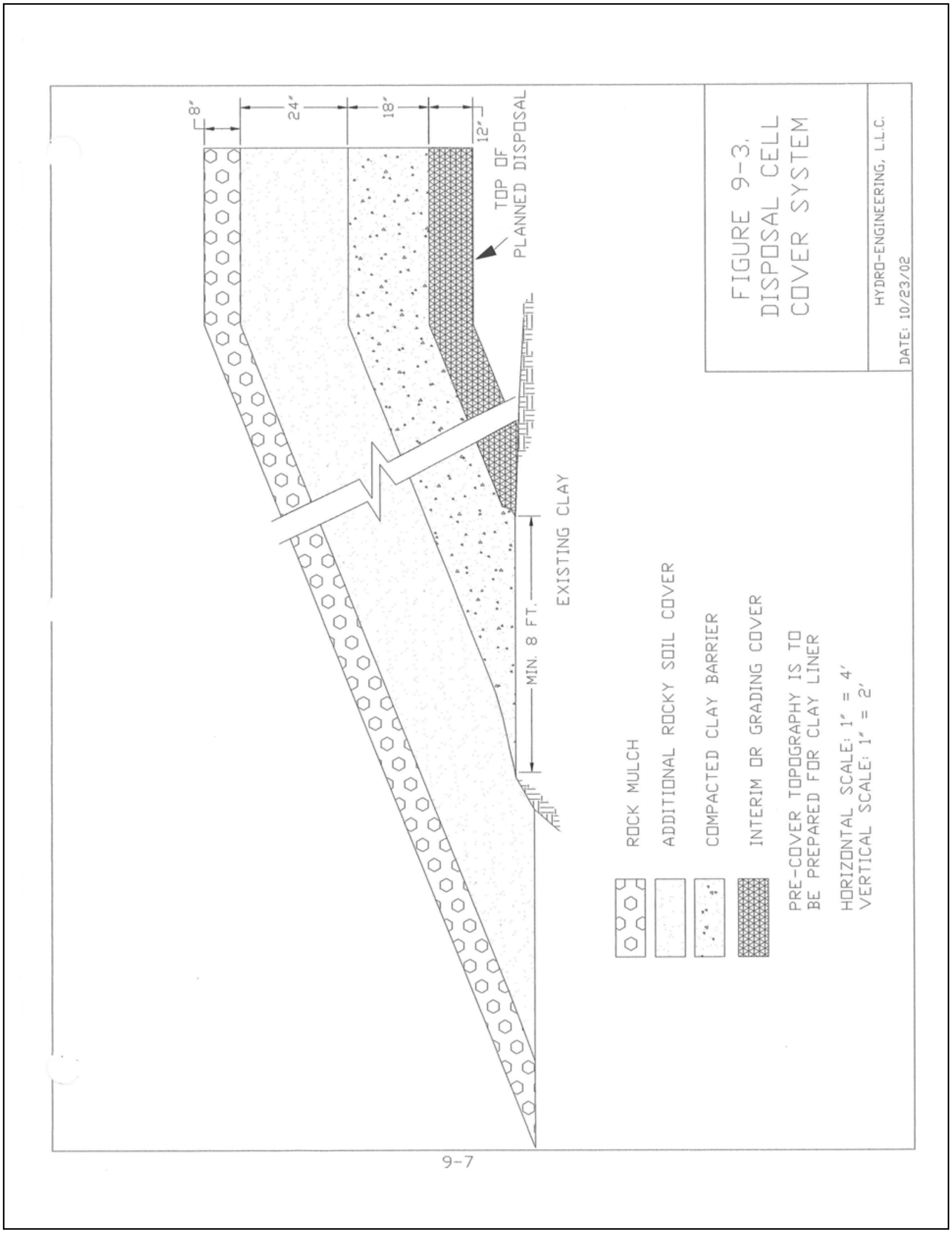
N
FIGURE 9-1. PRESENT TOPOGRAPHY AND CROSS-SECTION LOCATIONS
SCALE: 1"=200'
HYDRO-ENGINEERING, L.L.C.
DATE: 10/22/02


N
--LEGEND--
RM 7 *
WELLS TO BE PRESERVED
EXISTING CONTOURS
FILL CONTOURS FOR BASE OF CAP
0 CUT/FILL CONTOURS FOR BASE OF CAP
EDGE OF TAILINGS CELL
LIMITS OF EXISTING TAILINGS
NORTH DIKE
EAST DIKE
CROSS-VALLEY BERM
T1
T2
T3
T4
T5
T6
T7
RM 7
4450
4440
4430
4420
4410
4400
4390
4380
URANIUM ONE AMERICAS
RIVERTON, WYOMING
SHOOTARING CANYON URANIUM MILL SITE
TICABOO, UTAH
FIGURE 9-2A. FILL THICKNESS TO THE BASE OF THE CLAY BARRIER (FEET)
HYDRO-ENGINEERING, L.L.C.
4685 S. MAGNOLIA
CASPER, WY. 82604
DATE: 02/21/2003
REVISED FEB. 2003
REVISION BY: SMP



8"
24"
18"
12"
TOP OF
PLANNED DISPOSAL
EXISTING CLAY
MIN. 8 FT.
ROCK MULCH
ADDITIONAL ROCKY SOIL COVER
COMPACTED CLAY BARRIER
INTERIM OR GRADING COVER
PRE-COVER TOPOGRAPHY IS TO
BE PREPARED FOR CLAY LINER
HORIZONTAL SCALE: 1" = 4'
VERTICAL SCALE: 1" = 2'
FIGURE 9-3.
DISPOSAL CELL
COVER SYSTEM
HYDRO-ENGINEERING, L.L.C.
DATE: 10/23/02
9-7

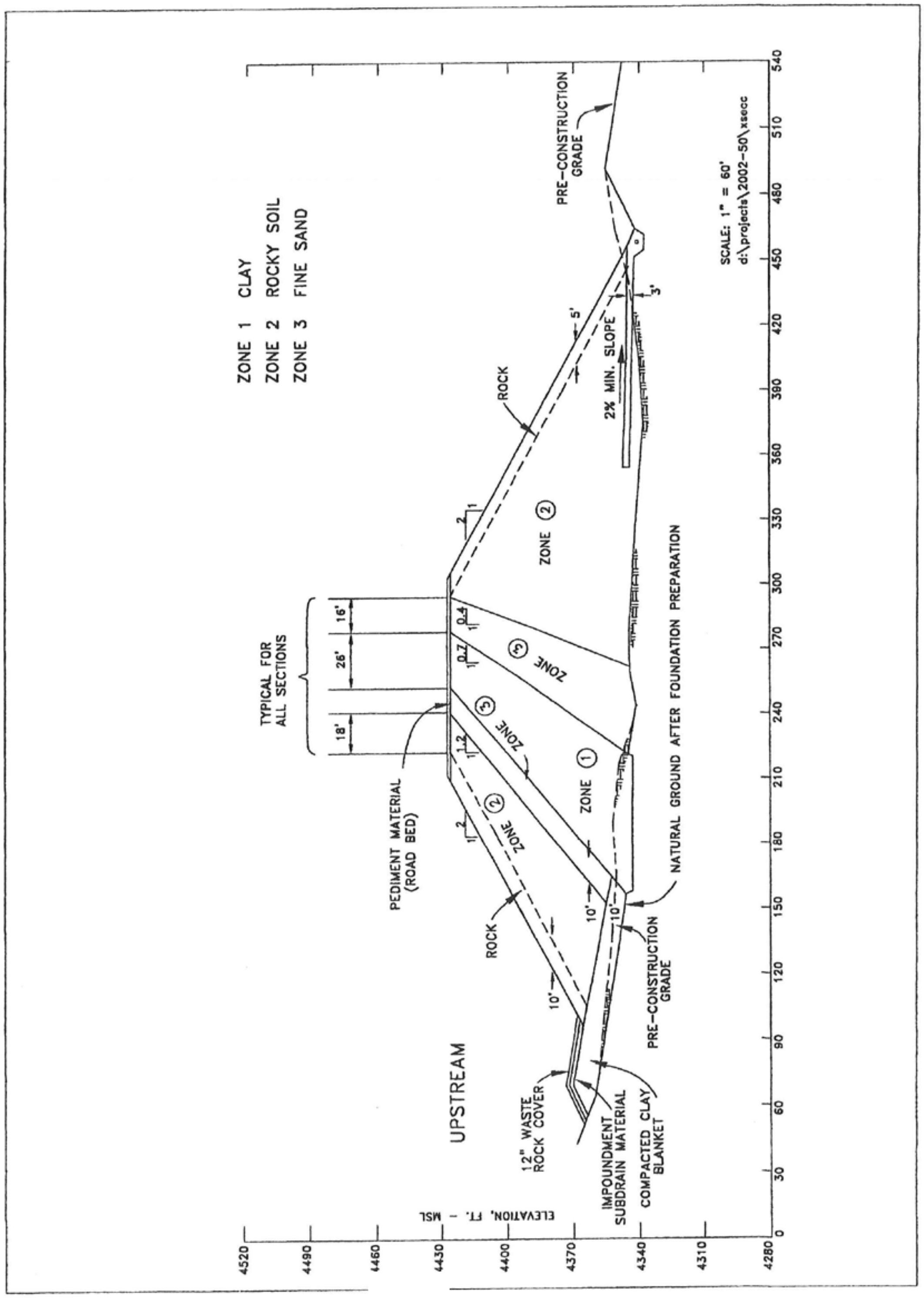


FIGURE 9-4. CENTER CROSS SECTION THROUGH SHOOTARING DAM

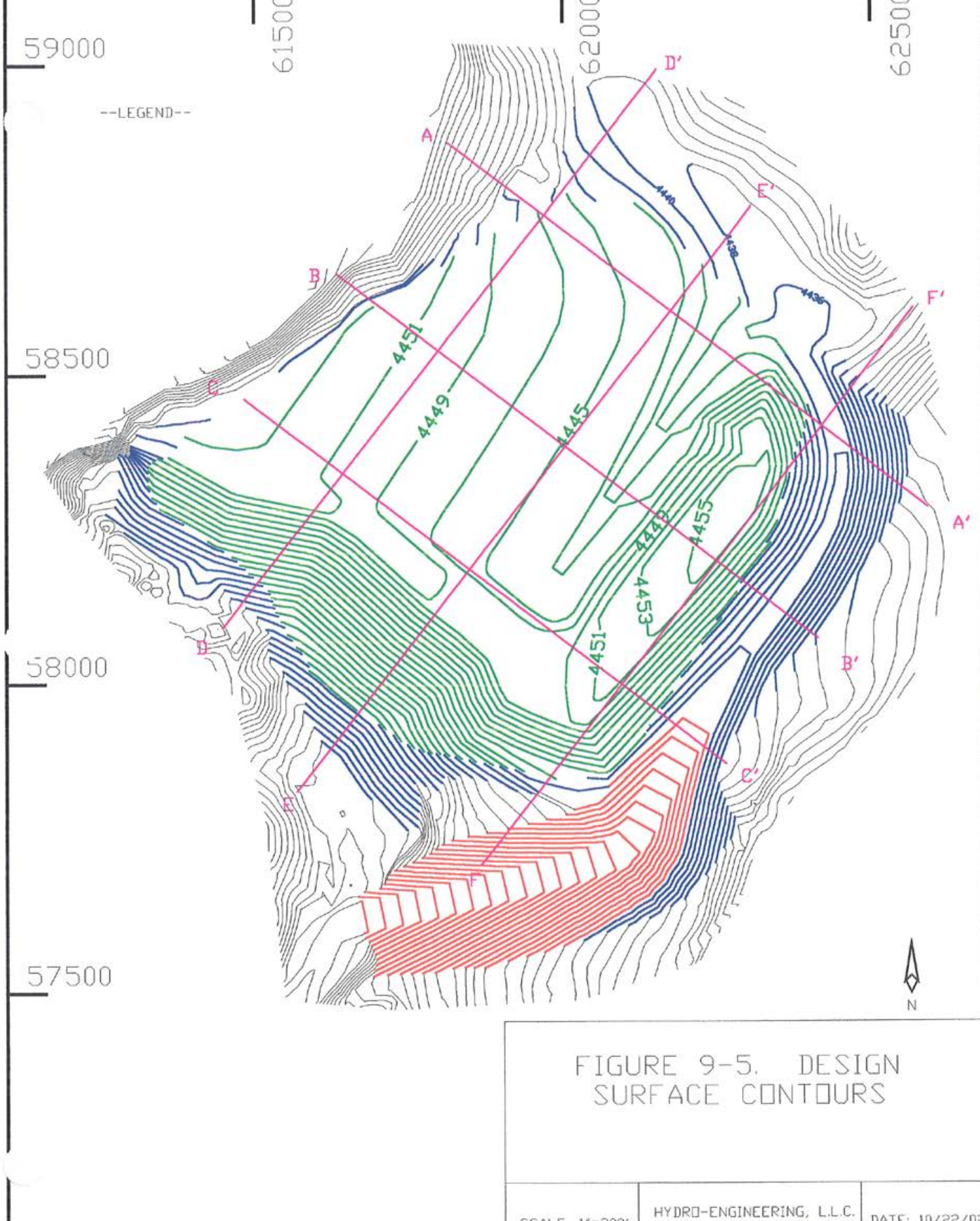


FIGURE 9-5. DESIGN SURFACE CONTOURS

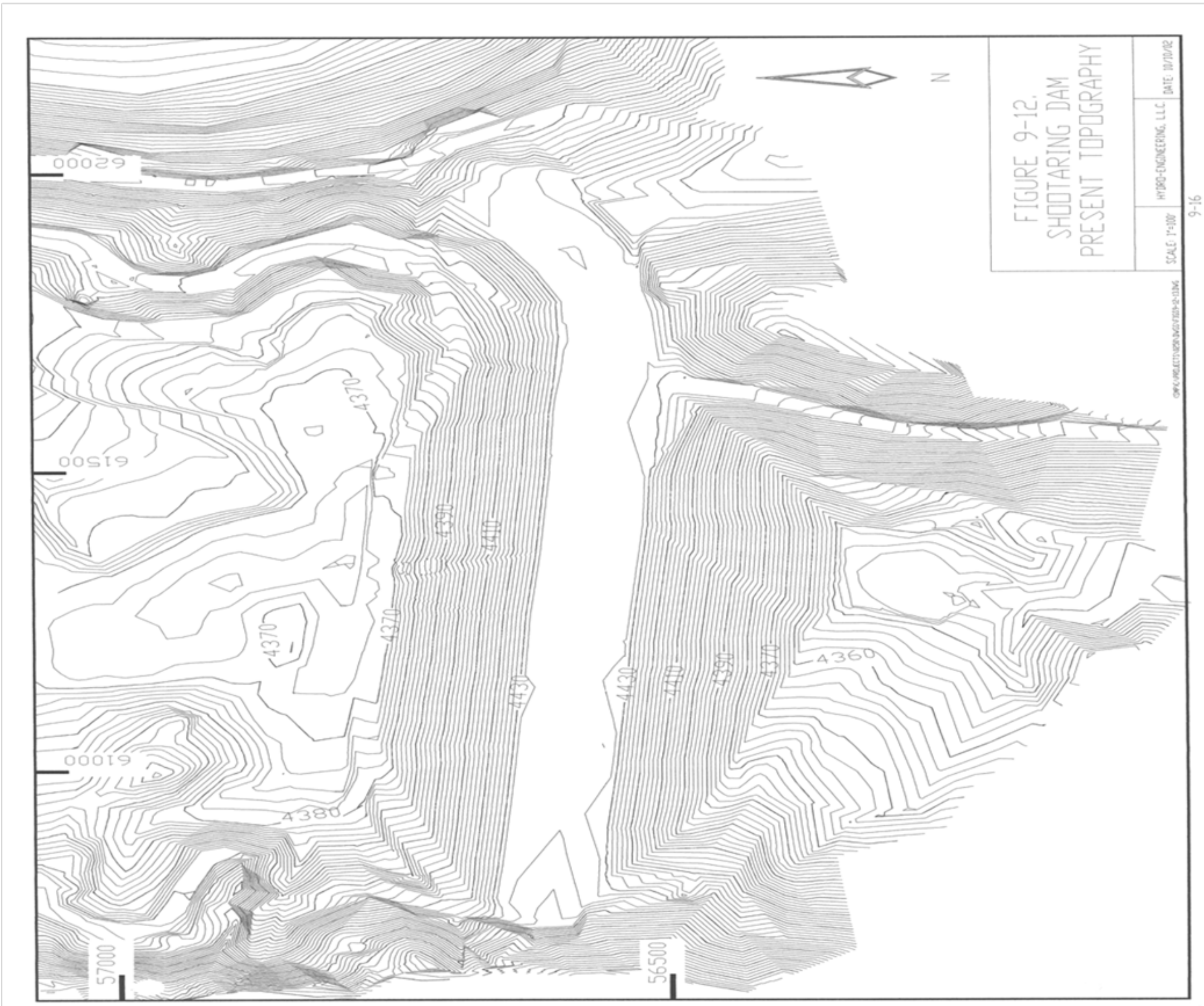


FIGURE 9-12.
SHOOTARING DAM
PRESENT TOPOGRAPHY
N
4370
4390
4410
4430
4380
4360
62000
61500
61000
57000
56500
9-16

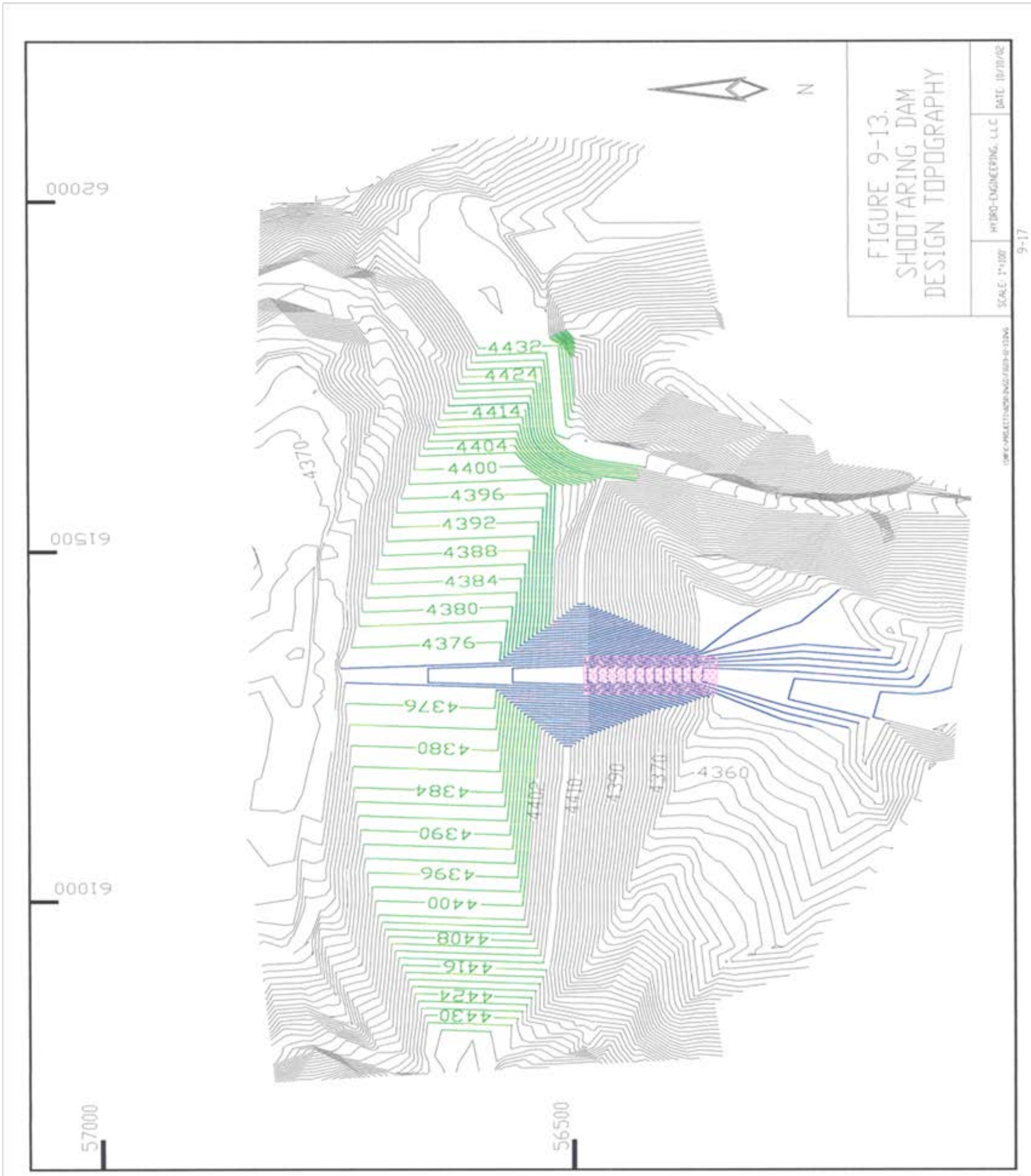
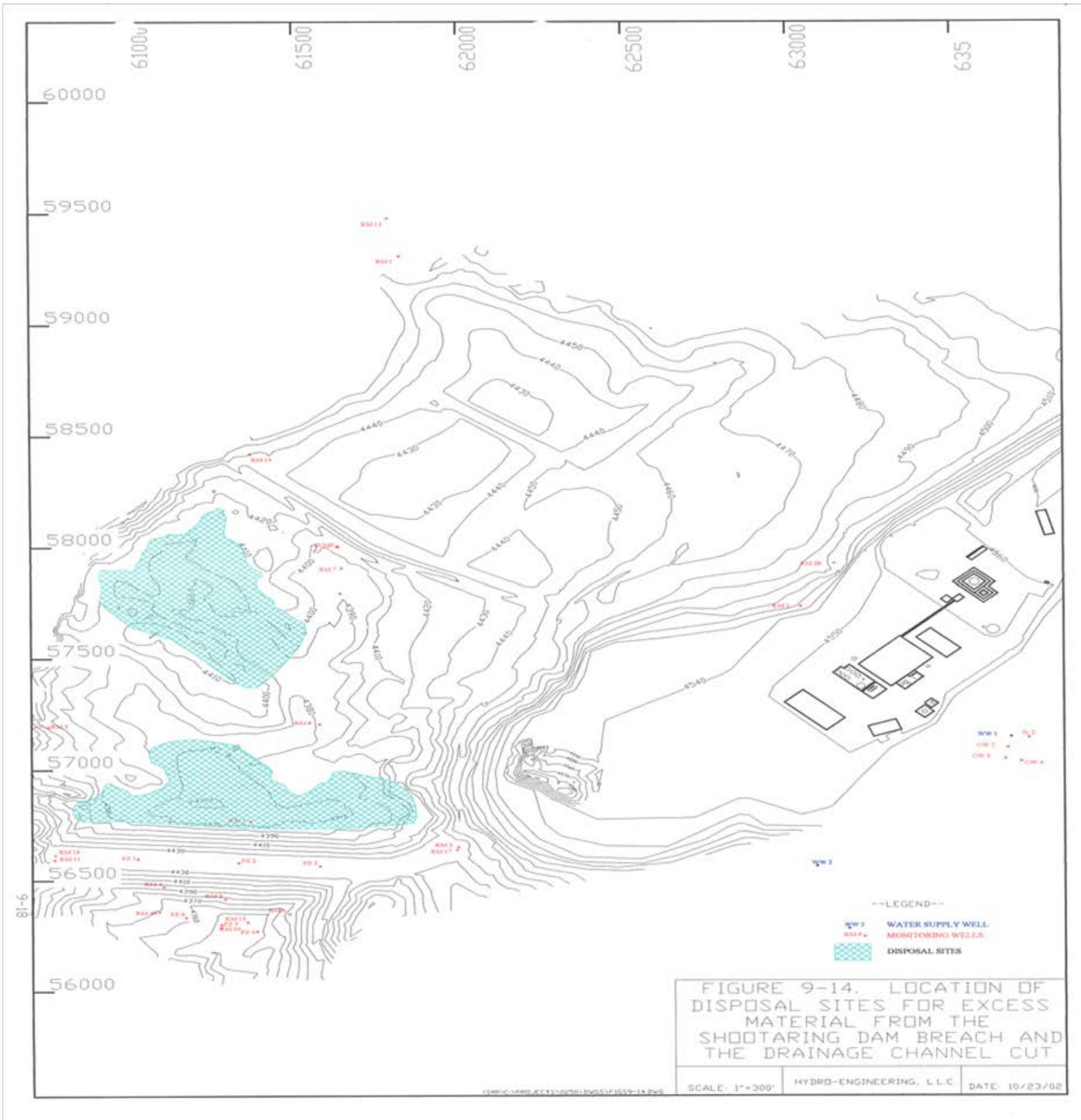


FIGURE 9-13.
SHOOTARING DAM
DESIGN TOPOGRAPHY
HYDRO-ENGINEERING, LLC
N
62000
61500
61000
57000
56500
4432
4424
4414
4404
4400
4396
4392
4388
4384
4380
4376
4370
4360



--LEGEND--
WATER SUPPLY WELL
MONITORING WELLS
DISPOSAL SITES
FIGURE 9-14. LOCATION OF DISPOSAL SITES FOR EXCESS MATERIAL FROM THE SHOOTARING DAM BREACH AND THE DRAINAGE CHANNEL CUT
SCALE: 1"=300'
HYDRO-ENGINEERING, L.L.C.
DATE: 10/23/02

10.0. DECOMMISSIONING AND TAILING RECLAMATION SCHEDULE

The decommissioning activities objective is to perform the tasks continuously once begun but may extend beyond the eighteen month period. Figure 10-1 illustrates major activities and estimated time frames for completion. Radiation safety and monitoring programs shall continue throughout the decommissioning and tailings reclamation process.

Figure 10-1 presents the schedule of reclamation activities at the Shootaring site. The decommissioning schedule for the Shootaring Canyon Mill has a six (6) month interval for salvage of milling components that have commercial value and are able to be released for unrestricted use. Table 8-2 presents a list of equipment anticipated for release during this period. This time interval can vary, as the components are made available for release. The cleanup at the toe of the Shootaring dam and the ore on top of the cross valley berm are the initial work items planned for tailings reclamation. The mill decommissioning is also planned to start during the early stages of the reclamation project. Time frames are estimated for each of the individual major tasks in the mill decommissioning with the total decommissioning estimated to last six months. The ore pile disposal into the tailings cell and the remainder of the tailings reclamation are scheduled to occur after the mill decommissioning. The total reclamation plan is for 18 months but could be extended significantly if significant gaps between some of the reclamation stages are required. Weather delays could result in a longer period of time between the start and finish of the reclamation. Also, laboratory and completion reports with regulatory review and approval could also require additional time between some reclamation tasks.

FIGURE 10-1. Schedule of Reclamation Activity at the Shootaring Canyon Site

		Time	Year 1	Year 2	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
GRAPHICAL EVENTS FOR RECLAMATION OF THE MILL SITE		Days	2005	2006	Jan'07	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
SECTION 11.1: MILL DECOMMISSIONING & SHAPING																
	11.1.0 DELAY IN SCHEDULE	730														
	11.1.1 GAMMA-SOIL RADIONUCLIDE RELATIONSHIP	4														
	11.1.2 AMMONIA TANK CONVERSION	1														
	11.1.3 TRUCK SCALE CLEANUP AND BUILDING DEMO	1														
	11.1.4 ORE HOPPER DEMO	10														
	11.1.5 ACID TANK & FOUNDATION DEMO	2														
	11.1.6 CCD CIRCUIT DEMO 70 % complete	4														
	11.1.7 MILL DEMO	20														
	11.1.8 TANKS AND FOUNDATIONS E. OF MILL DEMO	3														
	11.1.9 SODIUM CHLORATE TANK, FOUND. DEMO	2														
	11.1.10 CONCRETE TRENCH DEMO	3														
	11.1.11 TAILING SLURRY PIPELINE DEMO	2														
	11.1.12 REMOVAL OF CONTAMINATED SOILS FROM AROUND BUILDINGS	3														
	11.1.13 REMOVAL OF CONTAMINATED SOILS FROM ORE PAD AREA	3														
	11.1.14 RADIOACTIVE CONTAINMENT STORAGE AREA CLEANUP	5														
	11.1.15 SOIL VERIFICATION	3														
	11.1.16 RECONTOURING, SHAPING AND SEEDING MILL SITE AND BORROW	5														
	11.1.17 MANAGEMENT, REPORTING, TESTING & MONITORING	89														
	11.1.18 MOBILIZATION & DEMOBILIZATION	10														
SECTION 11.2: RECLAMATION OF TAILINGS																
	11.2.1 ORE ON CROSS VALLEY BERM & EAST DIKE	5														
	11.2.2 TOE OF DAM CLEANUP	10														
	11.2.3 MILL DEMO DISPOSAL	79														
	11.2.4 ORE DISPOSAL	15														
	11.2.5 CONTOURING CROSS VALLEY BERM & NORTH AND EAST DIKES	10														
	11.2.6 DRAINAGE CHANNEL CUT	15														
	11.2.7 CLAY COVER MATERIAL	20														
	11.2.8 ROCKY SOIL COVER MATERIAL	25														
	11.2.9 ROCK COVER MATERIALS	30														
	11.2.10 MONITORING WELL ABANDONMENT	20														
	11.2.11 MANAGEMENT, REPORTING, TESTING & MONITORING	229														

Note: Schedule subject to change due to weather or other unforeseeable circumstances, or contractor efficiency.
Delay in reclamation schedule due to improvement of the uranium market so as to secure investments for the possibility of reopening the mill.

Plateau Resources Limited
Operation and
Reclamation Schedule
Date: 10/22/02 revised 1/10/05

11.0. COST ANALYSIS FOR MILL DECOMMISSIONING AND TAILING RECLAMATION

Cost breakdown of the areas of work:

11.1 Cost Estimate for Mill Site Decommissioning

As presented, the decommissioning and reclamation activities are expected to take approximately two years to complete. Uranium One Americas prepared a cost estimate for the mill decommissioning, which includes the following assumptions:

1. The on-site work force will consist of the following estimated labor components:

   1 - Radiation Safety Officer
   3 - Radiation Technician
   1 - Lab Technician
   1 -Clerk
   1 -Demolition Superintendent/Foreman
   5- Equipment Operators
   1 -Equipment Mechanic Oiler
   1 -Oiler
   <u>5- Laborers</u>
   19

Personnel may be increased or decreased depending on the project activity or other specialist required for certain high risk areas.

2. The on-site equipment force will consist of the following estimated components:

   1 - Shear/Concrete Attachment/Excavator
   1 - Front End Loader
   1 - Grapple/Excavator
   2 - End Dump Trucks
   2 - Water Wagons
   1 - Fuel/Lube Truck
   1 - Motor Grader
   1- Welder
   <u>6- Scrapers</u>
   16

Additional equipment may be added or removed depending on the project activity, contractor preference or other special requirements.

11.1.0 Salvage of Mill Components: 180 days $0

Salvage of mill components is planned for the first six months of the reclamation operation:

TOTAL = $0 $0

11.1.1 Gamma-Soil Radionuclide Relationship: 4 days $10,904

Develop relationships between gamma readings and radium-226, natural uranium, and thorium-230 concentrations. For costing it is estimated to take four days to complete with the following crew:

Crew	Cost / Hour	Hours	Extension	Cumulative:
2 EA Radiation Technicians	26	64	1,664	
Misc. Hand Tools	10	24	240	

Soil Samples 30 samples@ $300/ea = 9.000

TOTAL = $ **10,904** **$10,904**

11.1.2 Ammonia Tank Conversion: 1 day $ **176**

Remove and dispose of any fluids per state and federal laws. Clean tank and foundation for release. Vent tank, remove all present fittings, and connect propane fittings. For costing it is estimated to take one day to complete with the following crew:

Crew	Cost/Hour	Hours	Extension	Cumulative
1 EA Laborers	12	8	96	
Misc. Hand Tools	10	8	80	

TOTAL = $176 $11,080

11.1.3 Truck Scale Cleanup and Building Demo: 1 day $1,220

Requires disassembly of scale building for disposal in tailings cell, and cleaning of the scale for release. For costing it is estimated to take one day to complete with the following crew:

Crew:	Cost/Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	4	600	
2 End Dump Trucks w/ Drivers	50	8	400	
1 Water Wagon w/ Operator	55	4	220	
		TOTAL =	**$1,220**	**$12,300**

11.1.4 Ore Hopper Demo: 10 days $20,280

Remove grizzly and wet scrubber and place into the tailings impoundment. Requires disassembly and backfilling of ore dump pocket. For costing it is estimated to take two weeks to complete with the following crew:

Crew:	Cost/Hour	Hours	Extension	Cumulative:
Crawler Excavator w/ Operator	90	40	3,600	
Front End Loader w/ Operator	65	80	5,200	
Welder & Truck	45	40	1,800	
End Dump Truck w/ Driver	50	80	4,000	
Shear w/ Operator	150	8	1,200	
2 EA Laborers	12	240	2,880	
Misc. Hand Tools	20	80	1,600	
		TOTAL =	**$20,280**	**$32,580**

11.1.5 Acid Tank and Foundation Demo: 2 days $1,480

Remove and dispose of any fluids in tanks per state and federal laws. Remove and crush tanks and foundations for placement into the tailings impoundment. For costing it is estimated to take two days to complete with the following crew:

Crew	Cost/Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	4	600	
Front End Loader w/ Operator	65	4	260	
2 End Dump Trucks w/ Drivers	50	8	400	
Water Wagon w/Operator	55	4	220	
		TOTAL =	**$1,480**	**$34,060**

11.1.6 CCD Circuit Demo: 12 days $18,560

Remove tanks and foundations for placement into the tailings impoundment. Remove and dispose of top 1 foot of soil beneath the foundation. For costing it is estimated to take two and a half weeks to complete with the following crew:

Crew:	Cost/ Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	80	12,000	
2 End Dump Truck w/ Drivers	50	80	4,000	
2 EA Laborers	12	80	960	
Misc. Hand Tools	20	80	1 600	
		TOTAL =	**$18,560**	**$52,620**

11.1.7 Mill Demo: 20 days $97,380

Remove equipment for placement into the tailings impoundment. For costing it is estimated to take four weeks to complete with the following crew:

Crew:	Cost/Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	160	24,000	
Grapple w/ Operator	150	160	24,000	
Front End Loader w/ Operator	65	130	8,450	
Welder and Truck	45	150	6,750	
2 End Dump Truck w/ Driver	50	290	14,500	
Water Wagon w/ Operator	55	160	8,800	
2 EA Laborers	12	640	7,680	
Misc. Hand Tools	20	160	3.200	
		TOTAL =	**$97,380**	**$150,000**

11.1.8 Tanks and Foundations E. of Mill: 3 days $14,970

Remove and dispose of any fluids in tanks per state and federal laws. Remove and crush tanks, sand filters and foundations for placement into the tailings impoundment. For costing it is estimated to take three days to complete with the following crew:

Crew	Cost/Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	24	3,600	
Grapple w/ Operator	150	24	3,600	
Front End Loader w/ Operator	65	34	2,210	
End Dump Truck w/ Driver	50	40	2,000	
Water Wagon w/ Operator	55	24	1,320	
I EA Laborers	12	120	1,440	
Misc. Hand Tools	20	40	800	
		TOTAL =	**$14,970**	**$164,970**

11.1.9 Sodium Chlorate Tank, Found. Demo: 2 days $14,412

Remove and dispose of any fluids in tanks per state and federal laws. Remove and crush tanks and foundations for placement into the tailings impoundment. For costing it is estimated to take 2 days to complete with the following crew:

Crew	Cost/Hour	Hours	Extension	Cumulative:
Shear w/ Operator	150	16	2,400	
2 End Dump Truck w/ Drivers	50	30	1,500	
1 EA Laborers	12	16	192	
Misc. Hand Tools	20	16	320	
Neutralization of Residual	1	LS	10.000	
		TOTAL =	**$14,412**	**$179,382**

11.1.10 Concrete Trench Demo: 3 days $9,288

Remove concrete trenches and cut piping for placement into the tailings impoundment. For costing it is estimated to take three days to complete with the following crew:

Crew:	Cost/Hour	Hours	Extension	Cumulative
Crawler Excavator w/ Operator	90	20	1,800	
Shear w/ Operator	150	20	3,000	
Water Wagon w/ Operator	55	24	1,320	
2 End Dump Truck w/ Drivers	50	48	2,400	
1 EA Laborers	12	24	288	
Misc. Hand Tools	20	24	480	
TOTAL =			**$9,288**	**$188,670**

11.1.11 Tailings Slurry Pipeline Demo: 2 days $1,552

Cut pipe into manageable sections for placement into the tailings impoundment. For costing it is estimated to take two days to complete with the following crew:

Crew:	Cost/Hour	Hours	Extension	Cumulative
Front End Loader w/	65	16	1,040	
Operator	12	16	192	
1 EA Laborers	20	16	320	
Misc. Hand Tools				
		TOTAL =	**$1,552**	**$190,222**

11.1.12 Removal of Contaminated Soils From Around Buildings: 3 days $15,000

Remove approximately 1 foot of soil from contaminated areas identified within the mill area for placement into the tailings impoundment. For costing it is estimated to take half of one week to complete with the following crew:

Crew:	Cost/Hour	Hours	Extension	Cumulative
2 EA. Scraper w/ Operators	135	40	5,400	
Motor Grader w/ Operator	75	20	1,500	
Crawler Excavator w/ Operator	90	20	1,800	
Front End Loader w/ Operator	65	20	1,300	
2 End Dump Truck w/ Drivers	50	40	2,000	
Water Wagon	55	40	2,200	
Misc. Hand Tools	20	40	800	
		TOTAL=	**$15,000**	**$205,222**

11.1.13 Removal of Contaminated Soils From Ore Pad Area: 3 days $15,240

Remove approximately 1 foot of soil from ore pad area for placement into the tailings impoundment. Also includes removal of fence in area. For costing it is estimated to take half of one week to complete with the following crew:

Crew:	Cost/Hour	Hours	Extension	Cumulative
2 EA. Scraper w/ Operators	135	40	5,400	
Motor Grader w/ Operator	75	20	1,500	
Crawler Excavator w/ Operator	90	20	1,800	
Front End Loader w/ Operator	65	20	1,300	
2 End Dump Truck w/ Drivers	50	40	2,000	
Water Wagon	55	40	2,200	
2 EA. Laborers	12	20	240	
Misc. Hand Tools	20	40	800	
		TOTAL =	**$15,240**	**$220,462**

11.1.14 Radioactive Containment Storage Area Cleanup: 5 days $12,250

Includes removal of all material and 3" of soil of entire area for placement into the tailings impoundment. For costing it is estimated to take one week to complete with the following crew:

Crew:	Cost/Hour	Hours	Extension	Cumulative
2 EA Scraper w/ Operator	135	20	2,700	
Motor Grader w/ Operator	75	20	1,500	
Water Wagon w/ Operator	*55*	20	1,100	
2 End Dump Trucks	50	40	2,000	
Front End Loader	65	30	1,950	
Shear w/ Operator	150	20	3.000	
		TOTAL=	**$12,250**	**$232,712**

11.1.15 Soil Verification: 3 days $10,248

Areas where soil cleanup was performed are to be scanned and verified to be cleaned to the approved standards. For costing it is estimated to take three days to complete with the following crew:

Crew	Cost /Hour	Hours	Extension	Cumulative:
2 EA Radiation Technicians	26	48		

<u>Soil Samples</u> 30 samples@ $300/ea = 9.000

		TOTAL =	**$ 10,248**	**$242,960**

11.1.16 Recontouring, Shaping and Seeding Mill Site and Borrow: 5 days $17,900

Grade site to match the surrounding area. Place soils and seeding where required for establishment of plant growth. For costing it is estimated to take three weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
Front End Loader w/ Operator	65	40	2,600	
Water Wagon w/ Operator	55	80	4,400	
2 End Dump Truck w/ Drivers	50	80	4,000	
Fann Tractor & Ace. w/ Operator	65	40	2,600	
2 EA Laborers	25	80	2,000	
Seed, Fertilizer & Mulch Cost				
5 Acres - $300 / Acre			1,500	
Misc. Hand Tools	20	40	800	
		TOTAL =	**$17,900**	**$260,860**

11.1.17 Management, Reporting, Testing & Monitoring: 89 days $1,048,300

The following is the cost to have on staff or on site the following people and or equipment & facilities during decommissioning activities. The time required is matched to the above mill site decommissioning items, which is twenty-six weeks. The personnel below will be performing the daily paper work, reporting, management of decommissioning activities, environmental and radiological surveys and testing, quality control testing, soil verification, monitoring and any other safeguards and requirements to establish a site which will meet the unrestricted use parameters. The average radon flux will be determined on the disposal cell based on 100 canister readings. Note the time allowed in this matches the time to perform the work in the decommissioning of the mill facility. These people will also be used in the reclamation of the tailings impoundment and the additional time and expense for them will be accounted for in that section. The cost to perform independent testing and monitoring is also given below, along with an estimate on preparing a detailed decommissioning plan and completion report.

Crew:	Cost / Month	Months	Extension	Cumulative
Radiation Safety Officer	5,300	6	31,800	
Radiaton Technician 3 EA	25,950	6	155,700	
Lab Technician for Testing	4,200	5	21,000	
Labor 3 EA	9,000	6	54,000	
Clerical	3,600	6	21,600	
Demolition Superintendent	4,500	6	27,000	
Utility Cost (Phone, Elec., etc.)	8,000	6	48,000	
Living Costs for Crew (19 people)	47,500	6	285,000	
Misc. Office Supplies	500	6	3,000	
Mechanic	3,000	6	18,000	

Oiler	2,200	6	13,200	
Environmental, Radiological & Other Required or Needed Quality Control & Testing Equipment Allowance	40,000	4	160,000	
Preparing a Detailed Completion for Decommissioning and Reclamation Report	1	LS	100,000	
Outside Analytical, testing and Calibration Costs	1	LS	80,000	
Facility Setup Costs	1	LS	30,000	
		TOTAL =	**$1,048,300**	**$1,309,160**

11.1.18 Mobilization & Demobilization: **10 days** **$77,000**

Move equipment to the site and then move off site. For costing assume equipment may have to come in from a total of 500 miles away. Therefore see the following cost estimate:

16 Pieces of Equipment @ 500 Miles X 2 Ways X $4.50/*Mile*	$72,000		
Misc. Mobilization Items-- 1 LS @ $5,000.00	$ 5.000		
TOTAL =	**$77,000**	**$1,386,160**	

11.2 Cost Analysis for Reclamation Tailings

As presented, the decommissioning and reclamation activities are expected to take approximately one and one-half years to complete. Uranium One Americas prepared a cost estimate for the tailings reclamation, which includes the following assumptions:

1. The on-site work force will consist of the following estimated labor components:
   1 - Radiation Safety Officer
   3- Radiation Technicians
   1 -Lab Technician
   1- Clerk
   1 -Construction Superintendent/Foreman
   6- Equipment Operators
   1 -Equipment Mechanic Oiler
   5- Laborers
   19

Personnel may be increased or decreased depending on the project activity or other specialist required for certain high risk areas.

2. The on-site equipment force will consist of the following estimated components:
   1 - Front End Loader
   1 -Crawler Excavator
   2 -End Dump Trucks
   2 - Water Wagons
   1 -Fuel/Lube Truck
   1 - Motor Grader
   1 - Crawler Dozer
   1 - Compactor
   1 -Farm Tractor w/ Discs
   6- Scrapers
   17

Additional equipment may be added or removed depending on the project activity, contractor preference or other special requirements.

11.2.1 Ore on Cross Valley Berm and East Dike: 5 days $7,400

Remove approximately 6,700 C.Y. of ore from the Cross Valley Berm and the East dike and place into the tailings impoundment. For costing it is estimated to take one week to complete with the following crew:

Crew:	Cost/ Hour	Hours	Extension	Cumulative
Crawler Dozer w/ Operator	130	40	5,200	
Water Wagon	55	20	1,100	
Compactor	55	20	1,100	
		TOTAL =	**$7,400**	**$ 7,400**

11.2.2 Toe of Dam Cleanup: 10 days $45,675

An area was identified for clean up near the toe of the tailings dam. Up to two feet of material may be required to be removed from this area. The total volume for removal from this area is 18,000 C.Y., all of which is to be disposed of in the tailings cell. Cost includes load, haul and placement. For costing it is estimated to take two weeks to complete with the following crew:

Crew:	Cost/Hour	Hours	Extension	Cumulative
4 EA Scraper w/ Operator	135	280	37,800	
Crawler Dozer w/ Operator	135	20	2,700	
Crawler Excavator w/ Operator	90	20	1,800	
2 End Dump Trucks w/ Drivers	50	40	2,000	
Water Wagon w/ Operator	55	15	825	
Compactor	55	10	550	
		TOTAL =	**$45,675**	**$53,075**

11.2.3 Mill Demo Disposal: 79 days $222,600

The mill area demolition is all to be placed in the tailings impoundment. Cost includes placement only. The total volume for disposal from the Mill Demo and Mill soil cleanup is 17,100 C.Y., all of which is to be disposed of in the tailings cell. To prevent settlement after placement of the mill demo material, all voids will be filled with a flowable fill. For costing it is estimated to take sixteen weeks to complete with the following crew:

Plowable Fill: 5,400 C.Y. @ $35.00 / C.Y. = $189,000

Crew:	Cost/Hour	Hours	Extension	Cumulative
Crawler Dozer w/ Operator	135	200	27,000	
Water Wagon w/ Operator	55	40	2,200	
Compactor	55	80	4.400	
		TOTAL=	**$222,600**	**$275,675**

11.2.4 Ore Disposal: 15 days $136,900

The ore stockpiles are to be placed in the tailings impoundment. Cost includes load, haul and placement. The total volume for disposal from the ore disposal including contaminated soil in the area is 65,500 C. Y., all of which is to be disposed of in the tailings cell. For costing it is estimated to take three weeks to complete with the following crew:

Crew:	Cost/Hour	Hours	Extension	Cumulative
6 EA Scraper w/ Operator	135	720	97,200	
Crawler Dozer w/ Operator	135	120	16,200	
Water Wagon w/ Operator	*55*	120	6,600	
Motor Grader w/ Operator	75	120	9,000	
Misc. Hand Tools	20	120	2,400	
Compactor	*55*	100	5,500	
		TOTAL =	**$136,900**	**$412,575**

11.2.5 Contouring Cross Valley Berm and North and East Dikes: 10 days $16,000

The contouring of the cross valley berm and the north and east dikes consists of a cut volume of 30,000 C.Y. For costing it is estimated to take two weeks to complete with the following crew:

Crew:	Cost/Hour	Hours	Extension	Cumulative
Crawler Dozer w/ Operator	135	80	10,800	
Water Wagon w/ Operator	55	40	2,200	
Motor Grader w/ Operator	75	40	3,000	
Compactor	55	40	2.200	
		TOTAL =	**$16,000**	**$428,575**

11.2.6 Drainage Channel Cut: 15 days $44,600

The drainage channel cut consists of a cut volume of 81,000 C.Y., and a fill volume of 9,700 C.Y. A significant portion of the channel cut volume may be placed as interim/grading cover. The proximity of the tailings and channel cut area allows placement in the tailings area without additional haul distance. For costing it is estimated to take three weeks to complete with the following crew:

Crew:	Cost/Hour	Hours	Extension	Cumulative
Crawler Dozer w/ Operator	135	120	16,200	
Water Wagon w/ Operator	55	80	4,400	
Motor Grader w/ Operator	75	40	3,000	
Crawler Excavator w/ Operator	90	80	7,200	
2 End Dump Trucks w/ Drivers	50	80	4,000	
2 EA Scraper w/ Operator	135	40	5,400	
Compactor	55	80	4.40Q	
		TOTAL =	**$44,600**	**$473,175**

11.2.7 Clay Cover Material: 20 days $213,000

Costing for the clay cover material includes loading, hauling, and placing. For costing it is estimated to take four weeks to complete with the following crew:

Tailings Area: 14.6 Ac x 43,560 x 1.5 FT/27 x 1.05 = 37,000 CY

Crew:	Cost/Hour	Hours	Extension	Cumulative
2 Crawler Dozer w/ Operator	135	320	43,200	
Water Wagon w/ Operator	55	160	8,800	
Motor Grader w/ Operator	75	80	6,000	
Crawler Excavator w/ Operator	90	160	14,400	
6 EA Scraper w/ Operator	135	960	129,600	
Compactor	55	120	6,600	
Farm Tractor w/ Disc	55	80	4.400	
		TOTAL=	**$213,000**	**$686,175**

11.2.8 Rocky Soil Cover Material: 25 days $262,800

Costing for the rocky soil cover material includes loading, hauling, and placing. For costing it is estimated to take five weeks to complete with the following crew:

Tailings Area: 14.6 Ac x 43,560 x 2 FT/27 x 1.05 = 52,000 CY

Crew:	Cost/Hour	Hours	Extension	Cumulative
2 Crawler Dozer w/ Operator	135	400	54,000	
Water Wagon w/ Operator	55	200	11,000	
Motor Grader w/ Operator	75	120	9,000	
Crawler Excavator w/ Operator	90	200	18,000	
6 EA Scraper w/ Operator	135	1,200	162,000	
Compactor	55	160	8.800	
		TOTAL=	**$262,800**	**$948,975**

11.2.9 Area F Soil Cover and Testing: 15 days $21,802

The area at the toe of Shootaring dam (designated as Area F) will be covered by 1.5 feet of rocky soil after verification of final cleanup. The verification process will require sampling and on-site testing with the procedure described in SOP HP-24. Following cleanup verification the area will be covered with rocky soil. For costing it is estimated to take 4 days to complete the sampling and 11 days to complete the earthwork with the following crew and resources:

Area F Sampling: 200 Samples

Crew:	Cost/Hour	Hours	Extension	Cumulative
2 EA Radiation Technicians	26	32	832	
Misc. Hand Tools	20	32	640	
			1472	

Materials:	Cost/ Unit	Units	Extension
Cell Counter	2500	1	2,500
Calibration Samples	100	10	1.000
			3,500

Area F Cover: 6.5 Ac x 43,560 x 1.5 FT/27 x 1.05 = 16,500 CY

Crew:	Cost/Hour	Hours	Extension	
1 Crawler Dozer w/ Operator	135	88	11,880	
Motor Grader w/ Operator	50	88	4,400	
Water Wagon w/Operator	55	10	550	
		TOTAL =	**$21,802**	**$970,777**

11.2.10 Rock Cover Materials: 30 days $272,550

Process, load, haul and place rock cover materials to the required thickness above the soil cover and on slopes.

ROCK PRODUCTION AND PLACEMENT CREW:

2EA	EXCAVATOR	@	$ 120 /HR/EA
2EA	DOZER	@	$ 130/HR/EA
3 EA	LOADER	@	$ 65 /HR/EA
1 EA	SCREEN	@	$100/HR/EA
1 EA	BLADE	@	$ 75 /HR/EA
2 EA	WATER TRUCK	@	$ 40/HR/EA
6 EA	HAUL TRUCK	@	$ 60/HR/EA
1 EA	MECHANICS	@	$ 40 /HR/EA
1 EA	OILERS	@	$ 20/HR/EA
2 EA	LABORERS	@	$ 12/HR/EA
1 LS	MISC. EXP.	@	$ 20/HR/EA
	TOTAL$/HR	**=**	**$1,414/HR**

Expect 2 rounds / HR / Truck — 6 EA x 20 CY / Load x 2 Loads / HR x 8 HR / Day
1,920 CY / Day

Therefore:	(8 HR / Day x $ 1,414 / HR) / 1,920 CY/Day		$5.90 /CY
	Royalty Payment @ $ 1.00 / CY		$ 1.00 /CY
	TOTAL $/CY	=	**$6.90 /CY**

Cost for Tailings Portion

Unsorted Material	- 4,000 C.Y. x $ 6.90 /CY		$27,600	
2" D50 Material	- 19,400 C.Y. x $ 6.90 /CY		$133,860	
6" D50 Material	- 7,200 C.Y. x $ 6.90 /CY		$49,680	
20" D50 Material	- 7,050 C.Y. x $ 6.90 /CY		$48,645	
24" D50 Material	- 1,850 C.Y. x $ 6.90 /CY		$12.765	
	TOTAL	=	**$272,550**	**$1,243,327**

11.2.10.1 Additional Cost Analysis Break Down of Rock Cover Materials:
The rock cover materials will be processed from the existing borrow shown on Figure 6-9. The smaller (<20" D50) material will be processed from the quarry and Shootaring Dam, and the larger material (>20" D50) will be processed from the quarry, the upstream and downstream faces of the Shootaring Dam, and original borrow areas for the mill and dam. The material is in sufficient quantity and sizes within the borrow areas. No blasting or crushing will be required to produce the rock cover material as designed, rather only separation of the different sizes out of the borrow material will be required. This material from the quarry will be produced by the use of the following types of equipment working together in the production and placement of the material. A Cat D9 size dozer will strip a very limited depth of soil medium and push the borrow material to a three (3) cubic yard size excavator. The excavator will be loading the borrow material onto the screening plant which will separate the required rock sizes from the borrow material. The product and the waste material will be stockpiled and/or loaded onto haul trucks for delivery to the tailings disposal facility for placement. The loading and stockpiling will be performed by the use of two (2) five (5) cubic yard size loaders. This will enable them to keep up with the production rates and haulage of the materials. As the pits advance, the dozer will shape and clean behind the operation. The material from the dam face will be produced using a Cat D9 or larger dozer to push the material from the top of the dam face to the bottom where it will be picked through with an excavator with a thumb attachment to sort out the large material. The excavator will then load the trucks for hauling to the placement site.

The product materials will be hauled to the site by the use of twenty (20) cubic yard haul trucks. The number of trucks will depend on the production rate and placement of the product materials. For costing, at this time, six (6) trucks will be used in the calculation at a cycle rate of two (2) rounds per hour per truck. The distance hauled will generally be under one (1) mile and as such, better cycle times may be attained, thus reducing the number of haul trucks required. The haul road will be maintained by the use of a motor grader or blade in conjunction with a water truck for dust control.

At the location of final placement of the rock products, the material will be dumped and spread by the use of an excavator. This will limit the amount of rock material pushed into the underlying medium by keeping machinery off the rock products. A low ground pressure dozer may do this work as well, but for our analysis, we felt that an excavator would be better suited.

In addition to the machine time cost we added in the cost of a support maintenance crew to keep up with the ongoing care of the equipment. This includes a mechanic, oiler, and two (2) laborers.

In our analysis we did not take credit for the production of two or more product materials at the same time, which we anticipate doing. Our cost analysis includes stripping, production, hauling, placing, maintenance and clean up to each required rock size. We feel that the cost of $6.90/CY of rock material produced, hauled and placed is conservative in the estimation of rock cost.

11.2.11 Monitoring Well Abandonment: 20 days $48,758

Includes abandonment of 24 sand packed wells. For costing it is estimated to take four weeks to complete with the following crew:

Crew:	Cost / Hour	Hours	Extension	Cumulative
Drill Rig w/ Crew	100	160	16,000	
2 Laborers	55	320	17,600	
Misc. Hand Tools	20	160	3.200	
			36,800	
Materials:	Cost / L.F.	L.F.	Extension	
Grout	2	5,979	11,958	
		TOTAL=	**$48,758**	**$1,292,085**

11.2.12 Management, Reporting, Testing & Monitoring: 229 days $1,652,500

The following is the cost to have on staff or on site the following people and or equipment & facilities during reclamation activities. The time required is matched to the above tailings site reclamation items, which is fifty-two weeks. The personnel below will be performing the daily paper work, reporting, management of reclamation activities, environmental and radiological surveys and testing, quality control testing, monitoring and any other safeguards and requirements to establish a site which is stable and requires no further monitoring care. Note these people are also used in the decommissioning of the mill site and the additional time and expense for them will be accounted for in that section. The cost to perform independent testing and monitoring is also given below, along with an estimate on preparing a detailed completion report.

Crew	Cost/Month	Months	Extension
Radiation Safety Officer	5,300	10	53,000
Radiation Technicians 3 EA.	25,950	10	259,500
Lab Technician for Testing	4,200	10	42,000
Labor 3 EA	9,000	10	90,000
Clerical	2,200	10	22,000
Construction Superintendent	4,500	10	45,000
Utility Cost (Phone, Elec., etc.)	8,000	10	80,000
Living Costs for Crew (19 people)	47,500	10	475,000
Misc. Office Supplies	2,000	10	20,000

Environmental, Radiological & Other Required or Needed Quality Control & Testing Equipment Allowance	33,000	12	396,000	
Completion Report	1	LS	100,000	
Radon Flux Testing	1	LS	15,000	
Outside Analytical, testing and Calibration Costs	1	LS	55.000	
		TOTAL	**$1,652,500**	**$2,944,585**

12.0 SUMMARY OF TOTAL COST FOR BONDING REQUIREMENTS

The total cost estimate for the Shootaring mill decommissioning and tailings reclamation is summarized in Table 12-1. All costs have been rounded to the nearest one hundred dollars. This total cost has a cost of $1,386,300 and $2,944,700 for the mill decommissioning and tailings reclamation respectively. The total cost for the reclamation project with a 15% contingency, 10% Uranium One Americas management overhead and long-term management cost is estimated to be $6,147,200.

Table 12-1. Summary of Cost for Mill Decommissioning and Tailings Reclamation

Events for Reclamation and Decommissioning of Shootaring Canyon Mill Facility		Cost
Decommission and Site Clean Up of Mill Facility		
11.1.0	Salvage of Mill Components	$ 0
11.1.1	Gamma-Soil Radionuclide Relationship	10,900
11.1.2	Ammonia Tank Conversion	200
11.1.3	Truck Scale Cleanup and Building Demo	1,200
11.1.4	Ore Hopper Demo	20,300
11.1.5	Acid Tank and Foundation Demo	1,500
11.1.6	CCD Circuit Demo	18,600
11.1.7	Mill Demo	97,400
11.1.8	Tanks and Foundations E. of Mill	15,000
11.1.9	Sodium Chlorate Tank, Found. Demo	14,400
11.1.10	Concrete Trench Demo	9,300
11.1.11	Tailings Slurry Pipeline Demo	1,600
11.1.12	Removal of Contaminated Soils from Around Buildings	15,000
11.1.13	Removal of Contaminated Soils from Ore Pad Area	15,200
11.1.14	Radioactive Containment Storage Area Cleanup	12,300
11.1.15	Soil Verification	10,200
11.1.16	Recontouring, Shaping and Seeding Mill Site and Borrow	17,900
11.1.17	Management, Reporting, Testing & Monitoring	1,048,300
11.1.18	Mobilization & Demobilization	77,000
	Total Cost for Decommission & Site Cleanup of Mill Area =	**$ 1,386,300**
Reclamation of Tailings Cell		
11.2.1	Ore on Cross Valley Berm and East Dike	$ 7,400
11.2.2	Toe of Dam Cleanup	45,700
11.2.3	Mill Demo Disposal	222,600
11.2.4	Ore Disposal	136,900
11.2.5	Contouring Cross Valley Berm & North and East Dikes	16,000
11.2.6	Drainage Channel Cut	44,600
11.2.7	Clay Cover Material	213,000
11.2.8	Rocky Soil Cover Material	262,800
11.2.9	Area F Soil Cover and Testing	21,800
11.2.10	Rock Cover Materials	272,600
11.2.11	Monitoring Well Abandonment	48,800
11.2.12	Management, Reporting, Testing & Monitoring	1,652,500
	Total Cost for Tailings Cell =	**$2,944,700**
	SUBTOTAL OF WORK =	**$4,331,000**
	15% CONTINGENCY =	**$ 649,700**
	URANIUM ONE AMERICAS **MANAGEMENT OVERHEAD @ 10% =**	**$ 498,100**
	(9/02) LONG TERM MAINTENANCE COST =	**$ 668,400**
	TOTAL COST OF MILL DECOMMISSIONING, SITE CLEANUP AND TAILINGS RECLAMATION WORK IS EOUAL TO	**$6,147,200**

13.0 FINAL DECOMMISSIONING COMPLETION REPORT

A final decommissioning report will be developed on the cleanup of the mill and the area surrounding the mill. The cleanup in the ore stockpile area will also be included with the mill decommissioning completion report.

A reclamation-as-built plan will be included in the completion report for the tailings reclamation. The tailings reclamation completion report will contain the volumes of materials placed in the disposal cell.

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APPENDIX A

BACKHOE PIT AND TEST HOLE INFORMATION

APPENDIX A

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TABLES

A.l BACKHOE PIT AND TEST HOLE INFORMATION

Appendix A presents the lithologic logs obtained from the backhoe pit, drill hole, hand auger, and backhoe-hand auger/drill hole combinations that were obtained during the site evaluation in June of 2002. Also presented in Appendix A are the results of the rock thickness tests that were performed on the Shootaring Dam rock.

Table A-1 presents the lithologic logs from the eleven backhoe pits used in the site evaluation. Table A-2 presents the lithologic logs from the fourteen drill holes used in the site evaluation. Table A-3 presents the lithologic logs from the thirty-six auger holes used in the site evaluation. In some locations, backhoe pits were used in combination with the hand auger or drill hole to determine the lithology. Table A-4 presents the lithologic logs from the twenty-one backhoe pit-auger/drill hole combinations that were used in the site evaluation. Table A-5 presents the results of the ten rock thickness checks that were performed on the upstream and downstream faces of the Shootaring Dam.

TABLE A-1. LITHOLOGIC LOGS OF BACKHOE PITS

LITHOLOGIC LOGS			
	top	*bottom*	
Backhoe Pit	*meas. (in.)*	*meas. (in.)*	*Descriptions*
CV4	0	1S	tan sand, rocks and clay
CV4	1S	30	very fine red sand, hard
DA1	0	39.6	rock, sand and clay
DAl	39.6	4S	brown clay w/little green clay
DD4	0	0	gravel @ surface
DD4	0	17	very fine red sand, some rock
DDS	0	12	gravel & red fine sand
DDS	12	17	large rocks & clay
DD6	0	4	rock & red sand
DD6	4	17	red very fine sand
DD7	0	12	gravel & red sand
DD7	12	17	very fine sand
DDS	0	6	tan very fine sand
DDS	6	12	clay, rock and sand
DD9	0	6	tan, very fine sand
DD9	6	12	clay, rock and sand
ED4	0	12	red sand and clay
ED4	12	4S	brown clay
OP33	0	15.6	red very_ fine sand
OP33	15.6	34.8	gray sand ore
OP33	34.8	40.8	tan fine sand
OP33	40.8	46.8	red very fine sand
T7	0	44.4	red very fine sand
T7	44.4	46.8	tails slimes
T7	46.8		rock layer

TABLE A-2. LITHOLOGIC LOGS OF DRILL HOLES

LITHOLOGIC LOGS			
	top	*bottom*	
Drill Holes	***meas. (in.)***	***meas. (in.)***	***Descriptions***
CV1	0	36	tan rock sand and clay
CV1	36	60	red very fine sand
CV1	60	228	red very fine sand
CV1	228	264	brown clay
CV1	264	324	red very fine
CV2	0	36	tan rock, sand and clay
CV2	36	300	very fine red sand
CV2	300	360	very fine red sand
CV2	360	492	very fine red sand
CV2	492	564	brown clay
CV2	564	588	white very fine sandstone Entrada
CV2	588	600	red silty, very fine sandstone
CV3	0	30	tan rock sand and clay
CV3	30	120	red very fine sand dry
CV3	120	180	red very fine sand w/ little moisture
CV3	180	216	red very fine sand w/ little moisture
CV3	216	258	brown clay, dry
CV3	258	300	red very fine sandstone, Entrada
ED1	0	12	rock sand and clay
ED1	12	48	red very fine sand
ED1	48	144	tan very fine sand and clay
ED1	144	162	brown clay
ED1	162	180	red very fine sandstone Entrada
ED3	0	12	rock sand and clay
ED3	12	53	tan very fine silty sand
ED3	54	72	red very fine sand
ED3	72	102	brown clay
ED3	102	120	red very fine sandstone Entrada
NDl	0	12	rock clay and sand
NDl	12	60	tan very fine sand
NDl	60	72	tan & brown very fine sand w/ piece of wood & plastic
NDl	72	84	concrete
NDl	84	108	red very fine sand
NDl	108	126	brown clay
NDl	126	144	red very fine sandstone Entrada
ND2	0	24	rock, clay and sand
ND2	24	84	very fine sand clays & rocks
ND2	84	120	tan very fine sand moist
ND2	120	180	brown sand & clay w/ some rock & wood plastic
ND2	180	240	very fine tan sand
ND2	240	288	very fine tan sand
ND2	288	312	clay
ND3	0	24	rock sand and clay
ND3	24	48	brown sand & clay w/ some wood
ND3	48	120	tan fine sand
ND3	120	168	tan fine sand

TABLE A-2. LITHOLOGIC LOGS OF DRILL HOLES. (cont'd.)

LITHOLOGIC LOGS			
Drill Holes	***top meas. (in.)***	***bottom meas. (in.)***	***Descriptions***
ND3	168	180	red very_ fine sand
ND3	180	204	brown clay
ND3	204	240	red very fine sand Entrada
ND3	240		white sandstone
T1	0	60	red very fine sand w/some clay
T1	60	90	very fine tan & brown sand w/ some clay
T1	90	108	rock, sand and clay
T1	108	126	red very fine sand
T1	126	162	brown clay
T1	162	174	red very fine sand
T2	0	18	red very fine sand
T2	18	60	tan very fine sand, tails
T2	60	108	tan very fine sand tails some slime
T2	108	120	red very fine sand
T2	120	126	brown sand clay
T2	126	168	brown clay
T2	168	180	liqht brown very fine sand
T3	0	24	red very fine sand
T3	24	60	tan fine sand tailings
T3	60	96	tan fine sand tailings w/little moisture
T3	96	204	tan fine sand tailings w/little moisture
T3	204	216	red very_ fine sand
T3	216	234	rock and fine sand
T3	234	270	red very fine sand
T3	270	348	brown clay
T3	348	372	red very fine sand1 Entrada
T4	0	18	very fine red sand
T4	18	60	tan tailinqs sand and slimes
T4	60	120	tan tailings sand
T4	120	156	shelby tube
T4	120	192	tan tailings sand
T4	192	216	rock and red very fine sand
T4	216		top of clay
T5	0	24	very fine red sand
TS	24	54	tailings slime
TS	54	66	rock sand and clay
TS	66	78	red very fine sand
TS	78		clay
T6	0	18	red very fine sand
T6	18	24	tailings slime
T6	24	72	red very fine sand
T6	72	96	gravel, tan sand
T6	96		clay

LITHOLOGIC			
Auger Holes	top meas.(in)	bottom meas. (in.)	Descriptions
C1	0	12	red clay w/ some white mudstone
C1	12	36	red very fine sandstone Entrada
C10	0	8	red clay w/some fine sand
C10	8	42	red clay w/green clay
C10	42	59	very fine red sand
C11	0	9	very fine sand and clay
C11	9	38	red very fine sand
C12	0	34	red clay w/some green sandy mudstone
C12	34		red very fine sandstone
C13	0	38	red clay w/ 20% green mudstone
C13	38	41	very fine red sand
C2	0	12	red clay w/approx. 20% white mudstone
C2	12	24	red clay w/approx. 20% white mudstone
C2	24	36	red very fine sandstone, Entrada
C3	0	34	red clay w/20% mudstone,little 1-6" rock
C3	34	38	red very fine sandstone Entrada
C5	0	18	red clay w/little red & white mudstone
C5	18	24	very fine red sandstone Entrada
C7	0	15	red clay
C7	15	21	very fine gray sandstone
C7	21	33	very fine sandstone
C7	33	66	red clay
C7	66		rock
C8	0	17	red clay
C8	17	20	very fine red sand
C8	20	69	clay, red
C8	69	84	very fine red sandstone
C9		7	red clay
C9	0 7	14	very fine red sand
C9	14	50	red clay w/ some green clay
C9	50	60	very fine red sandstone
096	0	42	red sand
096	42	72	red sand
096	72	102	red sand
097	0	54	red sand
097	54	66	red sand
098	0	18	red sand
098	18	30	red sand
098	30	42	red sand
099	0	42	red sand
099	42		white sand
NA1	0	5	rockisand and clay
NA1	5	21	very fine red sand
NA1	21	43	red clay w/little green clay

TABLE A-3. LITHOLOGIC LOGS Of AUGER HOLES. (cont'd.)

LITHOLOGIC LOGS			
	top	*bottom*	
Auger Holes	***meas. (in.)***	***meas. (in.)***	***Descriptions***
NA1	43	49	red clay and very fine sand
NA1	49	54	very fine red sand
NA1	54	85	red clay
NA1	85	86	red very fine sand Entrada
NA10	0	6	rock sand and clay
NA10	6	27	red sand, very fine
NA10	27	75	clay
NA10	75		sand
NA11	0	12	rock sand and clay
NA11	12	30	red very fine sand
NA11	30	58	brown clay w/ little green mudstone
NA11	58	64	red very fine sandstone Entrada
NA12	0	10	rock, sand and clay
NA12	10	20	very fine red sand
NA12	20	55	purple clay w/ some green clay
NA12	55	60	very fine red sandstone, Entrada
NA13	0	10	rock clay and sand
NA13	10	21	red very fine sand
NA13	21	38	purple clay w/ some green clay
NA13	38	40	very fine red sandstone Entrada
NA14	0	1	very fine red sand w/ small gravel
NA14	1	15	red very fine sand
NA14	15	53	brown clay w/ qreen clay
NA14	53	59	red very fine sandstone Entrada
NA15	0	15	sand, rock and clay
NA15	15	22	red sand
NA15	22	68	clay
NA15	68		red sand
NA16	0	10	rock sand and clay
NA16	10	25	red sand
NA16	25	55	clay
NA16	55		red sand
NA17	0	12	rock sand and clay
NA17	12	23	red sand
NA17	23	48	clay
NA17	48		sand
NA18	0	11	rock sand and clay
NA18	11	24	red sand
NA18	24	72	clay
NA18	72		sand
NA19	0	6	rock, clay and sand
NA19	6	16	sand
NA19	16	73	clay
NA19	73		sand

TABLE A-3. LITHOLOGIC LOGS OF AUGER HOLES. (cont'd.)

LITHOLOGIC LOGS			
	top	*bottom*	
AuaerHo/es	*meas. (in.J*	*me.as. fin.J*	*Descriptions*
NA2	0	15	sand rock and clay
NA2	15	27	very fine red sand
NA2	27	42	red clay
NA2	42	47	very fine red sand Entrada
NA20	0	10	rock, clay and sand
NA20	10	22	sand
NA20	22	44	clay
NA20	44		sand
NA3	0	7	rock sand and clay
NA3	7	20	very fine sand
NA3	20	71	red clay
NA4	0	11	rock sand and clay
NA4	11	20	fine red
NA4	20	78	clay
NA4	78		red Entrada
NAS	0	4	rock sand and clay
NAS	4	16	red fine sand
NAS	16	21	clay
NAS	21		red Entrada
NA6	0	12	rock, sand and clay
NA6	12	25	red sand
NA6	25	65	clay
NA6	65		sand
NA7	0	5	rock, sand and clay
NA7	5	25	red sand, fine
NA7	25	59	clay
NA7	59		sand
NAB	0	6	rock sand and clay
NAB	6	18	very fine red sand
NAB	18	29	red clay w/ little green clay
NAB	29	34	red clay & sandy green mudstone
NAB	34	37	red very fine sandstone Entrada
NA9	0	3	sand,rock and clay
NA9	3	14	very fine red sand
NA9	14	53	red clay w/ some green silty clay
NA9	53	60	red very fine sandstone, Entrada
OP31	0	8.4	red very fine sand
OP31	8.4	42	ore sand, hit rock

TABLE A-4. LITHOLOGIC LOGS OF DRILL OR AUGER HOLE/BACKHOE PITS

LITHOLOGIC LOGS			
	top	*bottom*	
Auaer/Backhoe Pit	*meas. fin.)*	*meas.Iin.J*	*Descriotions*
C4	0	60	red clay w/ green & brown mudstone approx. 15% up to 4" size
C4	60	66	sand and clay
C4	66	72	very fine red sand Entrada
C6	0	12	red clay dry, some rock
C6	12	36	moist clay, red some white sandstone
C6	36	58	Entrada sandstone
ED2	0	24	rock sand and clay
ED2	24	54	tan very fine sand
ED2	54	60	red sand
ED2	60	126	very fine to very coarse sand
ED2	126	142	clay
ED2	142	180	very fine red sandstone Entrada
NP1	0	12	rock sand and clay
NP1	12	21	Sand
NP1	21	38	clay
NP1	38		Sand
NP10	0	16	clav. sand and rock
NP10	16	28	Sand
NP10	28	100	clay
NP10	100		Sand
NP11	0	20	sand rock and clay
NP11	20	31	sand
NP11	31	86	clay
NP11	86		sand
NP2	0	10	rock sand and clay
NP2	10	32	red very fine sand
NP2	32	66	red clay w/ some white clay
NP2	66	72	red very fine sandstone Entrada
NP3	0	10	rock sand and clay
NP3	10	22	red sand
NP3	22	40	clay
NP3	40		red sand
NP4	0	12	rock clay and sand
NP4	12	19	red sand
NP4	19	69	clay
NP4	69		sand
NPS	0	7	rock, sand and clay
NPS	7	23	Sand
NPS	23	85	clay
NPS	85		sand
NP6	0	12	rock clay and sand
NP6	12	18	sand
NP6	18	27	rock clay and sand

TABLE A-4. LITHOLOGIC LOGS OF DRILL OR AUGER HOLE/BACKHOE PITS (cont'd.)

LITHOLOGIC LOGS			
	top	*bottom*	
Auger/Backhoe Pit	*meas. (in.)*	*meas. (in.)*	*Descriptions*
NP6	27	45	Sand
NP6	45	87	clay
NP6	87		Sand
NP7	0	12	rock clay and sand
NP7	12	22.5	Sand
NP7	22.5	53.5	clay
NP7	53.5		sand
NP8	0	10	clay, rock and sand
NP8	10	27	sand
NP8	27	64	clay
NP8	64		sand
NP9	0	21	clay, rock and sand
NP9	21	37	sand
NP9	37	71	clay
NP9	71		sand
OP32	0	4.8	very fine red sand
OP32	4.8	44.4	ore sand
OP32	44.4	55.2	red very fine sand
WP1	0	12	rock,clay and sand
WPl	12	30	Sand
WP1	30	54	clay
WPl	54		Sand
WP2	0	6	rock and clay
WP2	6	19	Sand
WP2	19	23	rock and clay
WP2	23	38	Sand
WP2	38	82	clay
WP2	82		Sand
WP3	0	6	rock and clay
WP3	6	18	Sand
WP3	18	28.5	rock clay and sand
WP3	28.5	42.5	Sand
WP3	42.5	72.5	clay
WP3	72.5		Sand
WP4	0	11	rock clay and sand
WP4	11	21	Sand
WP4	21	69	clay
WP4	69		Sand
WP5	0	14	rock clay and sand
WP5	14	28	Sand
WP5	28	45	rock clay and sand
WP5	48	51	Sand
WP5	51	91	clay
WP5	91		Sand

TABLE A-4. liTHOlOGIC LOGS OF DRILL OR AUGER HOLE/BACKHOE PITS (cont'd.)

LITHOLOGIC LOGS			
	top	*bottom*	
Auaer/Backhoe Pit	*meas.(in.)*	*meas. (in.)*	*Descriptions*
WP6	0	4	rock clay and sand
WP6	4	14	Sand
WP6	14	28	rock, clay and sand
WP6	28	45	Sand
WP6	45	62.5	clay
WP6	62.5		Sand

TABLE A-5. TAILINGS DAM ROCK THICKNESS

SAMPLE SITE	THICKNESS (FT.)
DS1	1.9
DS2	2.3
RT1	2.1
RT2	2.2
RT3	2.1
RT4	2.0
RT5	2.3
RT6	2.6
RT7	3.6
RT8	3.8

APPENDIX B

GAMMA SURVEY

APPENDIX B

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TABLES

B. 1 GAMMA Survey

A gamma survey was conducted to define the areas in the Shootaring mill and tailings area with elevated soil concentrations of radionuclides. Table B-1 of Appendix B presents the gamma survey readings. This table includes the site name, the gamma reading in 11Rihr and any location information relative to the measurement. Figures 3-2A and 3-2B show the location of the gamma sites for the west and east areas respectively. Figure 3-2C shows the gamma site locations for the east area in the mill area. The gamma values are posted on Figures 3-3A, 3-3B and 3-3C.

Two gamma meters were used to develop the gamma values for the Shootaring site. The first meter was Ludlum model 19 with a serial number of 34944, which was last calibrated on April 11, 2002. The second meter that was used is a Ludlum model 12S with a serial number 92512 and calibrated on May 28, 2002.

Radiation trained personnel did the ground surface gamma survey over two days to identify any areas that could have elevated gamma readings. No action was taken to shield the survey meters from shine caused by known gamma sources, such as, ore pile, mill process equipment, buildings and tailings depositional area. Survey meter calibrations are noted on the data sheets. Gamma survey procedure included function checks on the meter before use. The density of the data was determined based on non-uniformity of the data. For example, when there were rapidly changing exposure rates with distance, more data were recorded compared to areas where the exposure rates were uniform over large distances. As a gamma reading was recorded the hand held global positioning system (GPS) gave a position which was also recorded along with any notable landmarks. The gamma survey meter was carried at approximately one meter height above the ground.

Readings taken below the ground surface were only contact measurements for a qualitative determination only. Readings are used to estimate soil removal depth.

TABLE B-1. GAMMA SURVEY

Site Name	*Gamma Reading* (uR/hr)	*Location*
A1	5	
A10	8	
A11	7	
A12	8	
A13	8	
A14	6	
A15	7	
A16	7	
A17	7	
A18	6	edge of cover
A19	6	divide
A2	6	
A20	6	divide
A21	5	Entrada
A22	5	Entrada
A23	6	Entrada
A24		5 1/16 Bench
A25	6	S33/S34 S250 Entrada
A26	6	
A27	6	wind blown
A28	6	wind blown
A29	6	wind blown
A3	7	
A30	6	wind blown
A31	7	top pipe drain
A32	7	top drain
A33	7	edge rock
A34	7	
A35	7	top drain
A36	7	
A37	8	top ridge
A38	7	
A39	8	top of drain
A4	7	
A40	8	
A41	8	
A42	8	c. of draw
A43	8	
A44	7	
A45	7	edge of rock
A46	6	Entrada
A47	8	Entrada
A48	7	edge of rock
A49	7	
A5	7	
A50	8	
A51	9	N edge NP10
A52	10	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
	9	top drain
A54	10	
A55	8	top drain
A56	8	
A57	8	
A58	9	edge of rock
A59	10	edge of rock
A6	7	
A60	10	
A61	10	
A62	46	
A63	88	
A64	165	
A65	130	S side NP11
A66	30	
A67	9	
A68	8	
A69	8	
A7	7	top drain
A70	8	edge of rock
A71	8	Entrada slope break
A72	7	edge of rock
A73	8	
A74	9	
A75	11	edge of rock
A76	10	
A77	9	
A78	9	N side WPl
A79	9	
A8	7	
A80	9	edge of rock
A81	10	edge of rock
A82	10	
A83	10	
A84	10	S side WP3
A85	12	edge of rock
A86	11	edge of rock
A87	12	
A88	11	
A89	11	
A9	7	
A90	11	edge of rock
A91	17	edge of rock
A92	41	
A93	110	
A94	12	
A95	16	edge of rock
Bl	14	edge of clay & rock

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
B10	12	edge of rock
B11	12	edge of rock
B12	12	
B13	12	
B14	10	edge of clay
B15	9	toe of road
B16	9	toe of road
B17	10	edge of clay
B18	11	
B19	11	
B2	32	
B20	12	
B21	10	
B22	15	c. of 3 roads
B23	11	
B24	12	
B25	12	
B26	10	auger C1
B27	8	
B28	7	center road
B29	7	center road
B3	14	
B30	6	center road
B31	6	center road
B32	6	RM2
B33	7	toe slope
B34	7	RM2R
B35	7	toe slope
B36	6	
B37	6	
B38	8	
B39	9	edge of clay
B4	11	edge of clay
B40	11	
B41	11	
B42	10	ED4
B43	9	center road
B44	10	
B45	8	edge of clay
B46	7	
B47	7	
B48	7	center road
B49	7	toe slope
B5	9	outlet 6' culvert
B50	8	center road
B51	10	center road
B52	11	center road
B53	8	center road

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
B54	10	center road
BSS	10	center road
B56	13	center road
B57	11	center road
B58	11	center road
B59	12	
B6	9	toe of road
B60	13	
B61	15	comer of fence
B62	16	c. of gate
B63	8	fence
B64	10	
B65	9	
B66	9	
B67	9	center road
B68	10	clay
B69	10	clay, some fine sand
B7	10	edge of clay
B70	9	clay and some fine sand
B71	8	clay and some fine sand
B72	8	road
B73	7	
B74	7	
B75	6	road
B76	7	road
B77	7	road
B78	6	
B79	6	
B8	12	
B80	6	
B81	6	
B82	7	
B83	6	
B84	5	
B85	6	
B86	5	
B87	5	
B88	6	
B89	7	
B9	12	
B90	7	
B9l	8	
B92	8	
B93	7	
B94	7	
B95	7	
B96	6	
B97	11	draw

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
B98	13	draw
C100	8	
C101	7	
C20	9	c. gate
C21	9	fence
C22	11	fence
C23	11	fence
C24	10	fence bend
C25	11	fence
C26	11	fence
C27	12	fence corner
C28	10	top slope
C29	8	top slope
C30	11	top slope
C31	10	c. road
C32	8	
C33	8	top of slope
C34	7	top of slope
C35	8	top of slope
C36	8	cor. Fence
C37	9	fence
C38	7	
C39	7	
C40	7	
C41	8	
C42	7	cor. Fence
C43	10	fence
C44	8	fence
C45	7	cor. Fence
C46	7	
C47	7	
C48	7	
C49	9	cor. Fence
C50	8	fence
C51	8	fence toe
C52	9	fence
C53	11	c. gate
C54	10	
C55	11	
C56	12	
C57	14	old pit
C58	17	
C59	14	
C60	15	
C61	17	toe
C62	32	toe
C63	16	
C64	14	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
C65	14	
C66	24	
C67	24	
C68	15	
C69	14	
C70	17	
C71	12	
C72	12	
C73	14	
C74	10	
C75	8	
C76	8	
C77	8	cor. shop
C78	10	cor. shop
C79	8	
C80	21	
C8l	28	
C82	34	ditch
C83	13	
C84	7	
C85	7	
C86	7	
C87	7	
C88	9	road
C89	11	concrete
C90	11	
C91	7	pond dike
C92	7	pond dike
C93	6	pond dike
C94	7	top slope
C95	7	top slope
C96	6	
C97	5	
C98	7	
C99	7	
CV1	110	drill hole
CV2	90	sand cone & drill hole
CV3	105	drill hole
CV4	85	drill hole
CVB2	125	sand cone hole
Dl	28	NWCCD&road
D10	12	SE Ammonia Tank 3 ft. from CCD wall
D11	16	SEside CCD
D12	17	S sideCCD
D13	18	S sideCCD
D14	22	S sideCCD
D15	24	S sideCCD
D16	25	S side CCO

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
Dl7	25	S side CCD
DI8	24	S sideCCD
Dl9	20	SWsideCCD
D2	50	N side CCD center line of road
D20	18	W side CCD
D21	25	W side CCD at tailing line
D22	24	W side CCD at tailing line
D23	22	W sideCCD
D24	26	SW mill building
D25	40	W side mill building
D26	22	W side mill building
D27	25	W side mill building
D28	17	W side mill building
D29	27	W side mill building
D3	35	N side CCD & road
D30	16	W side mill building
D3l	16	NW side of switch gear room (mill building)
D32	19	NW side of generator & road
D33	21	SW side of generator/transformer
D34	19	W side of generator/transformer
D35	14	NW side of generator/transformer (8ft)
D36	16	W conveyor (10 ft)
D37	18	W conveyor
D38	17	NW conveyor
D4	25	N side CCD & road
D40	12	N side generator/transformer (10ft from fence)
D41	13	NW side power house
D42	11	N side power house
D43	11	N side power house
D44	11	NE side change dry
D45	12	E side change dry
D46	12	SE side change dry
D47	16	S side change dry & road
D48	23	NE side 600 area (&road), S side power house
D49	23	N side 600 area & road
DS	18	N side CCD & road
DSO	16	N side 600 area & road
D51	15	N side 600 area & road & N side switch gear
D52	1 5	N side switch gear
D53	21	NE side 600 area, 1 5 ft from building
D54	35	E side 600 area & large door
D55	100	E side 600 area on pump hose (preg tank?)
D56	40	E side SX & large door
D57	40	E side thickener outside (material in sump)
D58	26	NE side outside thickener
D59	30	E side thickener , 6 ft from sump
D6	15	NECCD & road
D60	20	E side thickener (tanks), 6ft from sump

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	Gamma Reading (uR/hr)	Location
D61	15	SE side tank (thickener), 6 ft from sump
D62	11	NE side shop
D63	11	E side shop
D64	12	SE side shop
D65	8	S side offence (inside mill yard), 30 ft from east side
D66	8	S side offence, 30ft inside
D67	7	S side offence, 30ft inside
D68	8	S side of lab air conditioner
D69	9	SE side lab, 5 ft from building
D7	14	NE Ammonia Tank & road
D70	7	E. side lab
D71	8	E. side lab
D72	8	NE side lab
D73	8	N side lab
D74	8	N side lab
D75	9	NW side lab
D76	10	W side lab
D77	9	W side lab
D78	9	W side lab
D79	10	SW side lab
D8	12	NE Ammonia across from Tank
D80	8	S side lab
D8l	9	S side lab
D82	9	SW side kerosene tank
D83	8	SW side kerosene tank & inside fence
D84	8	NE side kerosene tank & inside fence & NaChloride tank
D85	9	NW side kerosene tank & NaChloride tank
D86	10	NW side NaChlorate tank
D87	10	NE side NaChlorate tank & fence, 10 ft
D88	12	E side of fence (inside yard) across road from outside thickener
D89	11	E side inside fence
D9	11	SE Ammonia across from Tank
D90	10	E side inside fence
D9l	10	E side inside fence, across from pump house
D92	10	E side inside fence, across from water tank
D93	11	E side inside fence, across from water tank road
D94	10	E side inside fence
D95	11	E side fence at guard house
D96	28	3.5' N. Pit old lab
D96	8- 10	3.5' to 6' check gamma every 6", all red sand, no odor or texture change (sand is a little damp), contact rock at 7'
D96	8-9	check gamma every 6", all red sand, no color change
D97	5 - 8	second old pit, 0- 4.5' (sidewall)
D97	10	5.5', red sand
D98	8- 10	1.5' to 2.5'
D98	16	2.5', red color
D98	60	3.5', red color
D99	8 - 9	0'- 3.5', red sand

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
D99	11	3.5', white sand
DDl	7	
DD2	8	
DD3	7	
DD4	1 2	in pit, gravel@ surface, 0-1.5' v.f. red sand, some rock
DDS	15	0-1' gravel & red fine sand, 1-1. 5' large rocks & cl. Ore
DD6	10	top to bottom, 0-4" rock & red sand, 4"-1.5' red v.f. sand
DD7 (0-6")	16	
DD7 (I)	15	0-1' gravel & red sand, 1-1.5' v.f red sand
DD8 (0-6")	60	tan v.f sand
DD8 (6-12")	45	clay, rock & sand
DD9 (0-6")	19	
DD9 (6-12")	16	
El	12	walk gate
ElO	11	NEfuel dike
Ell	13	
El2	13	fence
E13	24	fence
El4	17	
ElS	23	toe dike
E16	48	
El7	38	NWbuilding
E18	25	Mill Sur. 4
E19	130	near ore
E2	14	
E20	34	
E21	36	SE side
E22	21	
E23	29	NE scale
E24	25	fence cor.
E25	so	fence cor.
E26	34	
E27	33	yellow post
E28	28	
E29	25	
E3	12	
E4	9	
E5	9	top slope
E6	9	cor building
E7	13	top slope
E8	18	
E9	11	SE fuel dike
Fl	65	east CVB
FlO	12	
F11	14	
Fl2	14	sump
F13	10	
Fl4	10	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location_*
Fl5	14	
F16	23	
Fl7	22	
F18	14	
F19	42	
F2	24	
F20	17	
F21	40	westCVB
F22	12	above WSC/CVB
F23	9	
F24	8	
F25	11	
F26	8	
F27	9	
F28	8	
F29	8	
FJ	30	
F30	8	
FJl	8	
F32	8	
F33	9	RM7
F34	9	
F35	9	
F36	10	
F37	9	
F38	10	
F39	8	
F4	18	
F40	9	
F41	10	
F42	8	
F43	9	
F44	12	
F45	8	
F46	7.5	
F47	9	
F48	10	
F49	10	
F5	34	
F50	8	
F51	9	
F52	14	
F53	12	East CB
F54	8	East Road
FSS	8	
F56	8	
F57	8	
F58	7	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
F59	7	road
F6	12	
F60	10	
F61	8	
F62	8	
F63	7	
F64	8	
F65	8	
F66	8	
F67	8	
F68	8	
F69	7	
F7	32	
F70	7	
F7l	8	rock pile
F72	9	
F73	8	
F74	7	
F75	7	
F76	6	
F77	7	
F78	7	
F79	8	
F8	13	
F80	7	
F81	6	
F82	5	
F83	6	
F84	10	
F85	6	
F86	7	
F87	6	
F88	7	
F89	7	
F9	14	
F90	6	
F91	6	SS
F92	6	
F93	10	
F94	7	
F95	7	
F96	6	
F97	6	
F98	6	SS
F99	6	above SS
Gl	6	
GlO	7	draw
GIOO	19	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR!hr)	*Location*
G101	20	
G102	11	
Gl03	9	
G104	10	
G105	19	edge of white depot
G106	18	
G107	24	
G108	25	
G109	16	
G11	8	draw
G110	16	
Glll	17	
G112	15	
G113	18	
G12	8	draw
Gl3	7	draw
Gl4	8	split in draw
Gl5	8	draw
G16	8	draw
Gl7	8	draw
G18	8	draw
Gl9	8	draw
G2	6	
G20	9	draw
G21	9	draw
G22	10	upst. draw
G23	7	E. 1116 33 draw
G24	8	draw
G25	8	draw
G26	8	draw
G27	7	draw
G28	7	draw
G29	7	edge draw SS
G3	7	
G30	8	draw
G31	7	draw
G32	7	draw SS
G33	7	road
G34	7	
G35	8	
G36	7	road
G37	7	road
G38	7	road
G39	7	
G4	8	
G40	7	road
G41	8	
G42	7	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
G43	7	road and draw
G44	7	
G45	8	road and draw
G46	8	road and draw
G47	9	draw
G48	9	RM8
G49	9	draw
G5	7	
G50	12	draw
GSl	12	draw
G52	9	5' top SS
G53	10	draw
G54	16	draw
G55	23	draw
G56	12	draw
G57	10	5' above
G58	11	5' above
G59	18	draw
G6	7	Entrada
G60	36	draw
G6J	12	1.5' head cut
G62	15	
G63	11	edge
G64	9	5' above
G65	8	10' above
G66	16	draw
G67	13	c. draw
G68	30	draw
G69	17	edge
G7	9	c. channel
G70	11	10'above
G71	16	edge
G72	13	edge
G73	14	draw
G74	19	
G75	12	
G76	10	top slope
G77	9	
G78	9	top slope
G79	12	bot. Slope
G8	8	edge SS
G80	11	
G81	8	top slope
G82	8	bot. slope
G83	7	bot. slope
G84	8	
G85	8	
G86	8	power switch

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
G87	8	top slope
G88	10	top point
G89	8	bot. slope
G9	7	edge SS
G90	8	bot. slope
G91	11	
G92	10	
G93	10	
G94	14	
G95	13	
G96	13	
G97	9	top slope
G98	14	
G99	18	
H1	18	
H10	9	
H1OO	42	0-3" sample
H10l (0-6")	31	0-6"
HlOl (6-12")	22	6-12"
H102	24	1'-1.5' below rock
H11	7	
H12	8	5' above
H13	7	draw
H14	7	draw
H15	7	draw
H16	7	draw
H17	7	draw
H18	7	draw
H19	7	top slope
H2	15	end of pipe
H20	7	
H21	8	draw
H22	7	draw
H23	8	draw
H24	8	draw
H25	9	draw
H26	10	draw
H27	10	draw
H28	12	
H29	15	toe 4' pile
H3	15	
HJO	18	toe 4' pile
I-131	] 5	toe 4' pile
H32	16	toe 4' pile
H33	18	toe 4' pile
H34	22	toe 4' pile
H35	16	
H36	18	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR!hr)	*Location*
H37	18	
H38	12	top w sand cover
H39	15	
H4	15	
H40	10	
H41	10	toe 20' pile
H42	10	toe 20' pile
H43	8	toe 20' pile in SS
H44	7	top SS
H45	9	
H46	8	start toe dam w. bt.
H47	9	
H48	12	
H49	14	
H5	14	
H50 (l)	20	start of deposit 20 in.
H50 (2)	15	5' above a rock
HSl	25	
H52 (1)	28	
H52 (2)	18	5' above sol. to 4'
H53	30	
H54	16	rock
H55	11	RM9
H56	22	rock edge
H57	23	
H58	19	last sign of acid
H59	12	
H6	13	
H60	9	
H61 (1)	8	edge of large and small rock
H61(2)	8	top edge of rock
H62	8	top edge of rock
H63	8	e. edge small rock
H64	8	
H65	8	
H66	8	
H67	8	rock sample
H68	8	rock sample
H69	8	rock sample
H7	l3	5' pile
H70	7	
H71	8	PZ
H72	7	dust NE cor.
H73	8	dust
H74	7	dust
H75	8	P2
H76	9	upst. Removed H7
H77	8	upst. Removed H7

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
H78	8	PZ
H79	8	closest rock M**1**
H8	21	
H80	8	NW cor. dust
H8l	8	SW cor. upst
H82	8	RM
H83	8	RM
H84	8	dust
H85	9	dust
H86	8	dust
H87	7	dust
H88	7	dust
H89	7	dust
H9	10	
H90	7	dust
H91	8	SE cor. Dust
H92	7	RM
H93	7	RM
H94	7	PZ
H95	9	sump
H96	7	PZ4
H97	7	draw
H98	7	draw
H99 (0-6")	12	0-6" sample
H99 (6-12")	17	6-12" sample
I1	12	S.W. Office
I10	12	
I11	16	
I12	11	
I13	24	
I14	8	
I15	8	
I16	8	
I17	12	center of road
I18	9	I. ofroad
I19	9	
I2	20	
I20	8	
I21	9	
I22	9	
I23	10	fence
I24	12	
I25	8	
I26	8	
I27	10	
I28	10	
I29	11	
I3	15	

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uRJhr)	*Location*
I30	12	
I31	10	
I32	12	
I33	11	
I34	9	weather stat.
I35	10	
I36	12	
I37	9	
I38	9	
I39	10	
I4	15	
I40	10	
I41	12	
I42	11	
I43	11	
I44	12	
I45	10	
I46	10	
I47	11	
I48	11	
I49	26	
IS	14	
I50	14	
I51	8	
I52	8	
I53	7	
IS4	8	
ISS	7	
IS6	7	
IS7	6	
IS8	6	
IS9	6	
I6	15	
I60	7	
I6l	6	
I62	6	
I63	6	
I64	6	
I65	6	
I66	6	
I67	7	
I68	14	
I69	12	
I7	16	
I70	13	light pole
I8	13	
I9	IS	
NCI(l)	90	0-6" sample

TABLE B-1. GAMMA SURVEY (cont'd.)

Site Name	*Gamma Reading* (uR/hr)	*Location*
NCl (2}	90	6-1 2"
NC2	20	
NC3	20	
NC4	20	
NCS	20	
NC6	20	
OP2 (3.7-4.2')	280	
OP2 (4.2-4.6')	170	
OP2 (ore)	650	
OP3 (1.3-2.9')	600	0-1.3' red v.f sand, 1.3-2.9' gray sand ore
OP3 (2.9-3.4')_	250	tan fine sand, some rock
OP3 (3.4-3.9}	160	red v.f sand

APPENDIX C

MATERIALS PROPERTIES

APPENDIX C

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APPENDIXC

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FIGURES

C.l Tailings and Ore Physical Properties

Samples were taken from the tailings and the ore piles and tests were run on these samples to determine the physical properties of these materials for use in the design of the tailings reclamation plan. Gradation results from tailings samples T3, T4 and T7 are presented in Tables C-1, C-2, and C-3, respectively. Tailings samples T3 and T4 are tailings sand samples and tailings sample T7 is a sample of the tailings slime. Tables C-4, C-5, and C-6 present the gradation results from ore samples OP31, OP32, and CV4, respectively. Ore samples OP31 and OP32 were taken directly from the ore piles. Ore sample CV4 was taken from the cross-valley benn at a depth of0"-5".

TABLE C-1. Gradation Results for Tailings Sample T3, 8' – 10'8"

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LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Urainium One Americas Shootaring Canyon
Lab ID: C02060335-007
Client Sample ID: T3 8-10'8"

Report Date: 07/08/02
Collection Date: 06/05/02
Date Received: 06110/02
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCL/QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Moisture	5.1	%		0.1		USDA26	06112102 10:27 / vh
RADIONUCLIDES -TOTAL							
Radium 226	45.6	pCi/g-dry		0.1		E903.0	06127102 03:08 / rs
Radium 226 precision	1.6	±				E903.0	06127102 03:08 / rs
Thorium 230	12.4	pC/lg-dry		0.1		E907.0	06121102 10:30 / ph
Thorium 230 precision	0.5	±				E907.0	06121102 10:30 / ph
Uranium	100	pCi/g-dry		0.01		SW6020	06123102 02:47 / smd
SIEVES							
0.125 Inch Sieve, Passed	99.9	%		1.0		ASA15-2	06126102 07:00 / lmh
0.125 Inch Sieve, Retained	ND	%		1.0		ASA15-2	06126102 07:00 / lmh
0.185 Inch Sieve, Passed	99.4	%		1.0		ASA15-2	06126102 07:00 / lmh
0.185 Inch Sieve, Retained	ND	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 12 Sieve, Passed	97.7	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 12 Sieve, Retained	1.6	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 20 Sieve, Passed	95.1	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 20 Sieve, Retained	2.6	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 60 Sieve, Passed	61.5	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 60 Sieve, Retained	33.6	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 100 Sieve, Passed	23.7	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 100 Sieve. Retained	37.8	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 200 Sieve, Passed	4.8	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 200 Sieve, Retained	18.9	%		1.0		ASA15-2	06126102 07:00 / lmh

Reporl **Ddinitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

TABLE C-2. Gradation Results for Tailings Sample T4, 10'- 13'

ENERGY LABORATORIES, INC. - 2393 Salt Creek Highway (82601) ·P.O. Box 3258 • Casper, WY 82602
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LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Uranium One Americas Shootaring Canyon
Lab ID: C02060335-008
Client Sample ID: T4 10'-13'

Report Date: 07/08/02
Collection Date: 06/05/02
Date Received: 06/10/02
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Moisture	9.4	%		0.1		USDA26	06112102 10:27 / vh
RADIONUCLIDES- TOTAL							
Radium 226	51.8	pCi/g-dry		0.1		E903.0	06127102 03:17 / rs
Radium 226 precision	1.9	±				E903.0	06127102 03:17 / rs
Thorium 230	28.8	pCi/g-<lry		0.1		E907.0	06121102 10:30 / ph
Thorium 230 precision	0.8	±				E907.0	06121102 10:30 / ph
Uranium	21.5	pCi/g-dry		0.01		SW6020	06123102 02:50 / smd
SIEVES							
0.125 Inch Sieve, Passed	98.3	%		1.0		ASA15-2	06126102 07:00 / lmh
0.125 Inch Sieve, Retained	1.7	%		1.0		ASA15-2	06126102 07:00 / lmh
0.185 Inch Sieve, Passed	96.5	%		1.0		ASA15-2	06126102 07:00 / lmh
0.185 Inch Sieve, Retained	96.5	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 12 Sieve, Passed	92.8	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 12 Sieve, Retained	3.7	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 20 Sieve, Passed	90.0	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 20 Sieve, Retained	2.8	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 60 Sieve, Passed	76.3	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 60 Sieve, Retained	13.7	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 100 Sieve, Passed	26.7	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 100 Sieve, Retained	49.6	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 200 Sieve, Passed	6.2	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 200 Sieve, Retained	20.6	%		1.0		ASA15-2	06126102 07:00 / lmh

Report Definitions:
RL - Analyte reporting limit.
OCL - Quality control limit.
MCL - Maximum contaminant level.
NO - Not detected at the reporting limit.

TABLE C-3. Gradation ResuJts for TaiJings SJime T7

ENERGY LABORATORIES, INC. ·2393SaltCreekHighway(82601) ·P.O. Box3258 ·Casper, WY82602
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LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Uranium One Americas Shootaring Canyon
Lab ID: C02060335-009
Client Sample ID: T7

Report Date: 07/08/02
Collection Date: 06/05/02
Date Received: 06/10/02
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date I By
PHYSICAL PROPERTIES							
Moisture	41.0	%		0.1		USDA26	06112102 10:27 I vh
RADIONUCLIDES - TOTAL							
Radium 226	139	pCi / lg-dry		0.1		E903.0	06127102 03:21 / rs
Radium 226 precision	5.0	±				E903.0	06127102 03:21 / rs
Thorium 230	3800	pCi / g-dry		0.1		E907.0	06/21102 10:30 / ph
Thorium 230 precision	25.0	±				E907.0	06121/02 10:30 / ph
Uranium	3880	mg/kg-dry		0.02		S\{\'6020	06123102 03:01 / smd
SIEVES							
0.125 Inch Sieve. Passed	93.1	%		1.0		ASA15-2	06126102 07:00 / lmh
0.125 Inch Sieve, Retained	6.9	%		1.0		ASA15-2	06126102 07:00 / lmh
0.185 Inch Sieve, Passed	80.0	%		1.0		ASA15-2	06126102 07:00 / lmh
0.185 Inch Sieve, Retained	13.1	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 12 Sieve, Passed	60.1	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 12 Sieve, Retained	20.0	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 20 Sieve, Passed	40.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Retained	19.2	%		1.0		ASA15-2	06126/02 07:00 / lmh
No. 60 Sieve, Passed	22.7	%		1.0		ASA15-2	06126/02 07:00 / lmh
No. 60 Sieve, Retained	18.2	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Passed	16.6	%		1.0		ASA15-2	06126/02 07:00 / lmh
No. 100 Sieve, Retained	6.1	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 200 Sieve, Passed	10.9	%		1.0		ASA15-2	06/26102 07:00 / lmh
No. 200 Sieve, Retained	5.7	%		1.0		ASA15-2	06126102 07:00 / lmh

Report **Definitions:**
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
NO - Not detected at the reporting limit.

TABLE C-5 Gradation Results for Ore Sample OP31

ENERGY LABORATORIES, INC. • 2393 Salt Creek Highway (82601) ·P.O. Box 3258 • Casper, WY 82602
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LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Uranium One Americas Shootaring Canyon
Lab ID: C02060335-00I
Client Sample ID: OPI (OP3l)

Report Date: 07/08/02
Collection Date: 06/06/02
Date Received: 06110/02
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCLI QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Moisture	1.8	%		0.1		USOA26	06/12/02 10:27 / vh
SIEVES							
0.125 Inch Sieve, Passed	91.1	%		1.0		ASA15-2	06126102 07:00 /lmh
0.125 Inch Sieve, Retained	8.9	%		1.0		ASA15-2	06126102 07:00 / lmh
0.1851nch Sieve, Passed	NO	%		1.0		ASA15-2	06126102 07:00 / lmh
0.185 Inch Sieve, Retained	NO	%		1.0		ASA15-2	06126102 07:00 /lmh
No. 12 Sieve, Passed	88.1	%		1.0		ASA15-2	06/26102 07:00 /lmh
No. 12 Sieve, Retained	2.4	%		1.0		ASA15-2	06126102 07:00 /lmh
No. 20 Sieve, Passed	85.1	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 20 Sieve, Retained	3.0	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 60 Sieve, Passed	61.2	%		1.0		ASA15-2	06126102 07:00 /lmh
No. 60 Sieve, Retained	23.9	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 100 Sieve, Passed	24.5	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 100 Sieve, Retained	36.7	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 200 Sieve, Passed	6.6	%		1.0		ASA15-2	06/26/02 07:00 /lmh
No. 200 Sieve, Retained	17.9	%		1.0		ASA15-2	06126102 07:00 /lmh

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
NO - Not detected at the reporting limit.

TABLE C-6 Gradation Results for Ore Sample OP32

ENERGY LABORATORIES, INC. ·2393Sai!CreekHighway(82601)·P.O Box3258 ·Casper, WY82602
Toll Free 888.235.0515 • 307.235.0515 • Fax 307.234.1639 • casper@energylab.com • www.energylab.com

LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Uranium One Americas Shootaring Canyon
Lab ID: C02060335-002
Client Sample ID: OP2 (OP32)

Report Date: 07/08/02
Collection Date: 06/06/02
Date Received: 06/10/02
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Moisture	3.3	%		0.1		USDA26	06/12/02 10:27/ vh
SIEVES							
0.125 Inch Sieve, Passed	94.2	%		1.0		ASA15-2	06/26/02 07:00 /lmh
0.125 Inch Sieve, Retained	5.8	%		1.0		ASA15-2	06/26/02 07:00 /lmh
0.185 Inch Sieve, Passed	93.4	%		1.0		ASA15-2	06/26/02 07:00 /lmh
0.185 Inch Sieve, Retained	ND	%		1.0		ASA15-2	06/26/02 07:00 /lmh
No. 12 Sieve, Passed	90.7	%		1.0		ASA15-2	06/26/02 07:00 /lmh
No. 12 Sieve, Retained	2.7	%		1.0		ASA15-2	06126102 07:00 /lmh
No. 20 Sieve, Passed	86.5	%		1.0		ASA15-2	06/26/02 07:00 /lmh
No. 20 Sieve, Retained	4.2	%		1.0		ASA15-2	06/26/02 07:00 /lmh
No. 60 Sieve, Passed	60.8	%		1.0		ASA15-2	06/26/02 07:00 /lmh
No. 60 Sieve, Retained	25.7	%		1.0		ASA15-2	06/26/02 07:00 /lmh
No. 100 Sieve, Passed	25.5	%		1.0		ASA15-2	06/26/02 07:00 /lmh
No. 100 Sieve, Retained	35.3	%		1.0		ASA15-2	06/26/02 07:00 /lmh
No. 200 Sieve, Passed	6.2	%		1.0		ASA15-2	06/26/02 07:00 /lmh
No. 200 Sieve, Retained	19.3	%		1.0		ASA15-2	06/26/02 07:00 /lmh

TABLE C-6. Gradation Results for Ore Sample CV4 on Cross Valley Berm, O"-5"

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Toll Free 888.235.0515 • 307.235.0515 • Fax 307.234.1639 • casper@energylab.com • wwwenergylab.com

LABORATORY ANALYTICAL REPORT

Client: US Energy
Project: Uranium One Americas Shootaring Canyon
Lab ID: C02060335-010
Client Sample ID: CV4 0-0.5

Report Date: 07108102
Collection Date: 06104102
Date Received: 06110102
Matrix: SOIL

Analyses	Result	Units	Qual	RL	MCL/QCL	Method	Analysis Date / By
PHYSICAL PROPERTIES							
Moisture	NO	%		0.1		USOA26	06112102 10:27 / vh
RADIONUCLIDES- TOTAL							
Radium 226	45.8	pCilg-dry		0.1		E903.0	06127102 03:31 / rs
Radium 226 precision	1.6	±				E903.0	06127102 03:31 / rs
Thorium 230	56.2	pCilg-dry		0.1		E907.0	06121102 10:30 / ph
Thorium 230 precision	1.0	±				E907.0	06121102 10:30 / ph
Uranium	71.5	pCIIg-dry		0.01		SW6020	06123102 03:13 / smd
SIEVES							
0.1251nch Sieve, Passed	91.9	%		1.0		ASA15-2	06126102 07:00 / lmh
0.125 Inch Sieve, Retained	8.1	%		1.0		ASA15-2	06126102 07:00 / lmh
0.185 Inch Sieve, Passed	90.5	%		1.0		ASA15-2	06126102 07:00 / lmh
0.185 Inch Sieve, Retained	1.4	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 12 Sieve, Passed	88.7	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 12 Sieve, Retained	1.8	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 20 Sieve, Passed	85.7	%		1.0		ASA15-2	06/26/02 07:00 / lmh
No. 20 Sieve, Retained	3.0	%		1.0		ASA15-2	06/26102 07:00 / lmh
No. 60 Sieve, Passed	61.4	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 60 Sieve, Retained	24.3	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 100 Sieve, Passed	23.4	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 100 Sieve, Retained	38.0	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 200 Sieve, Passed	5.7	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 200 Sieve, Retained	17.7	%		1.0		ASA15-2	06126102 07:00 / lmh

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. NO- Not detected at the reporting limit.

C.2 Radon/Infiltration Barrier Physical Properties

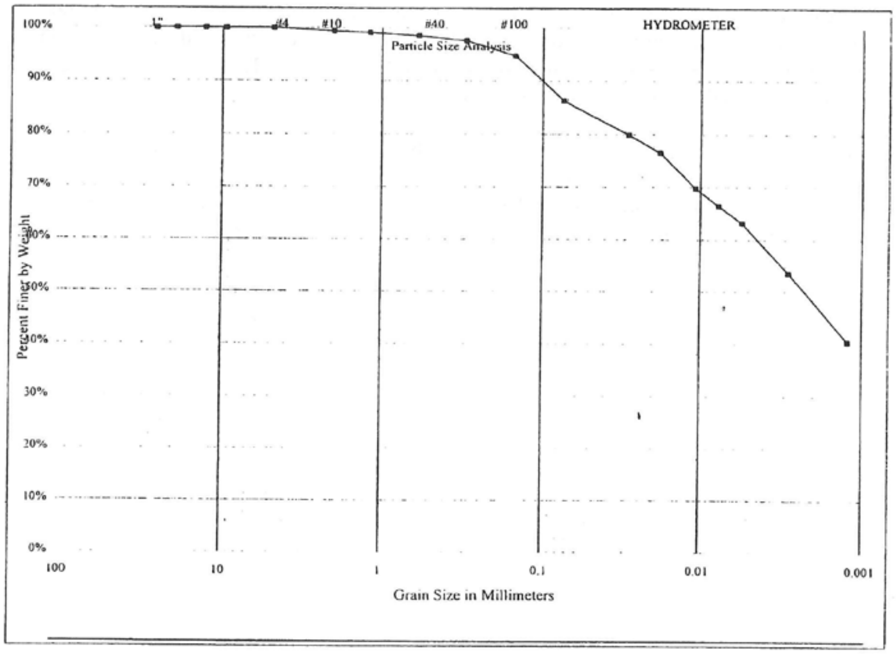
Clay samples were taken from various locations at the site to determine physical properties for the clay that is to be used for the radon/infiltration barrier in the tailings cell. Gradation results for clay samples NPll, NP10, NP6, WP4, NP4, C4, and DAl are presented in Tables C-7, C-8, C-9, C-10, C-11, C-12, and C-13, respectively. Samples NP11, NPIO, NP6, WP4, and NP4 were taken from backhoe pits around the existing tailings cell where the clay liner system was in place. Sample C4 was taken from the exposed clay east ofthe east dike. Sample DA1 was taken from a backhoe pit on the top of the Shootaring Canyon Dam. Table C-14 presents the liquid limits, plastic limits, plasticity indexes and lab permeability results for these same samples. Moisture density analyses were performed on the samples from NPll, NP10, NP6, C4, and Dam 1. Tables C-15 through C-19 present the results of these tests.

Double ring infiltrometer tests were performed on the clay at various locations to determine the in-situ permeability of the clay. Figures C-1, C-2, C-3, C-4, C-5, C-6, and C-7 present the results of these infiltrometer tests in locations WPl, WP2, NP2, NP3, NP5, NP7, and NP8, respectively. Figure C-8 presents evaporation test results that were performed at locations NP2 and NP5.

TABLE C-7. Gradation Results for Clay Sample NP11

SIEVE & HYDROMETER TEST ASTM D422

IME SAMPLE NO.:	NP-11	DATE RECEIVED	06/20/2002
CLIENT:	US Energy	TYPE OF SAMPLE	
CLIENT SAMPLE NO.:	NP-11		
SOIL DESCRIPTION:	Weak red clay w/ white clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	100.0%
3/8"	9.5200	100.0%
NO. 4	4.7600	100.0%
NO. 10	2.0000	99.4%
NO. 16	1.1900	99.1%
NO. 30	0.5900	98.5%
NO. 50	0.2970	97.6%
NO. 100	0.1490	94.7%
NO. 200	0.0740	86.3%
Hydrometer Range	0.0283	79.9%
	0.0181	76.5%
	0.0108	69.8%
	0.0077	66.4%
	0.0055	63.1%
	0.0028	53.5%
	0.0012	40.5%

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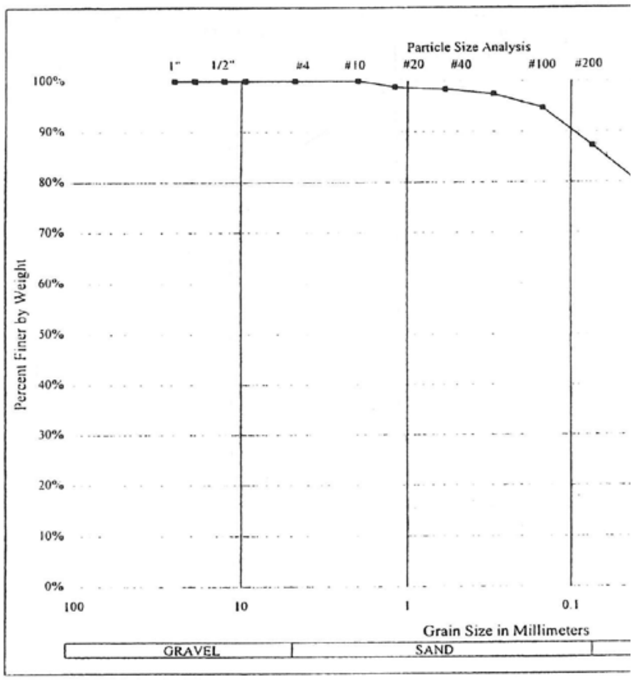
TABLE C-8. Gradation Results for Clay Sample NP10

SIEVE & HYDROMETER TEST AST

IME SAMPLE NO.:	NP-10	DATE RECEIVED:	
CLIENT:	US Energy	TYPE OF SAMPLE	
CLIENT SAMPLE NO.:	NP-10		
SOIL DESCRIPTION:	Weak red clay w/ white clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	100.0%
3/8"	9.5200	100.0%
NO. 4	4.7600	100.0%
NO.10	2.0000	100.0%
NO. 16	1.1900	98.8%
NO. 30	0.5900	98.3%
NO. 50	0.2970	97.4%
NO. 100	0.1490	94.6%
NO. 200	0.0740	87.2%
Hydrometer Range	0.0287	76.5%
	0.0187	69.8%
	0.0110	64.9%
	0.0078	63.2%
	0.0056	56.7%
	0.0029	47.0%
	0.0012	39.2%

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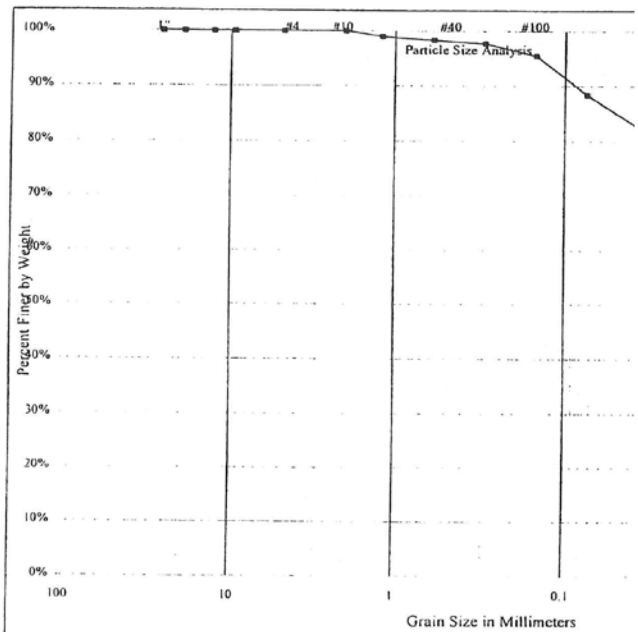
TABLE C-9. Gradation Results for Clay Sample NP6

SIEVE & HYDROMETER TEST AST

IME SAMPLE NO.:	NP-6	DATE RECEIVED
CLIENT:	US Energy	TYPE OF SAMPLE
CLIENT SAMPLE NO.:	NP-6	
SOIL DESCRIPTION:	Weak red clay w/ white clay	



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	100.0%
3/8"	9.5200	100.0%
NO. 4	4.7600	100.0%
NO.10	2.0000	100.0%
NO. 16	1.1900	99.0%
NO. 30	0.5900	98.3%
NO. 50	0.2970	97.7%
NO. 100	0.1490	95.4%
NO. 200	0.0740	88.4%
Hydrometer Range	0.0283	80.6%
	0.0181	77.2%
	0.0108	68.7%
	0.0078	65.4%
	0.0056	60.5%
	0.0026	50.6%
	0.0012	41.1%

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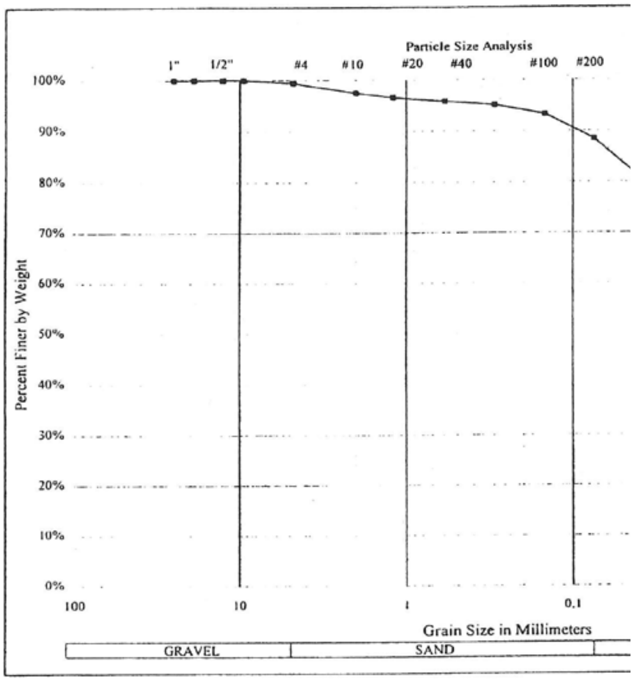
TABLE C-10. Gradation Results for Clay Sample WP4

SIEVE & HYDROMETER TEST AST

IME SAMPLE NO.:	WP-4	DATE RECEIVED	
CLIENT:	US Energy	TYPE OF SAMPLE	
CLIENT SAMPLE NO.:	WP-4		
SOIL DESCRIPTION:	Weak red clay w/ white clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	100.0%
3/8"	9.5200	100.0%
NO. 4	4.7600	99.4%
NO.10	2.0000	97.5%
NO. 16	1.1900	96.5%
NO. 30	0.5900	95.8%
NO. 50	0.2970	95.1%
NO. 100	0.1490	93.2%
NO. 200	0.0740	88.4%
Hydrometer Range	0.0286	77.4%
	0.0186	70.8%
	0.0109	67.6%
	0.0079	61.1%
	0.0056	57.9%
	0.0029	48.8%
	0.0012	37.8%

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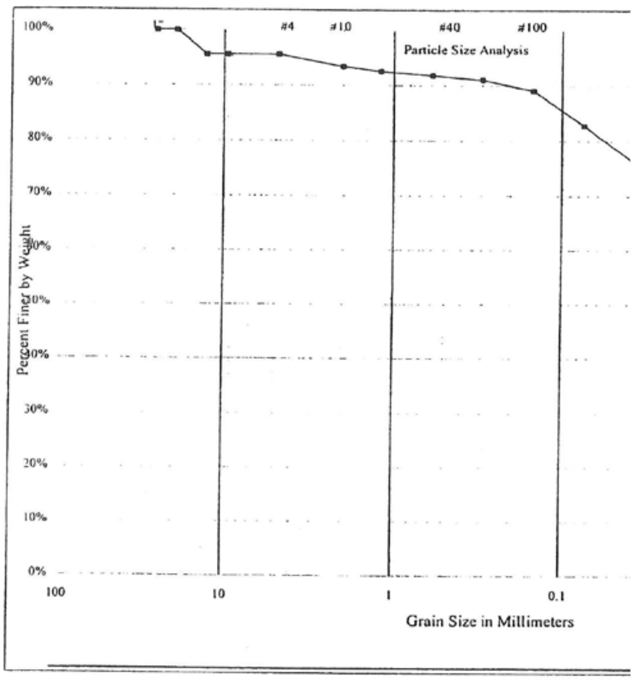
TABLE C-11. Gradation Results for Clay Sample NP4

SIEVE & HYDROMETER TEST AST

IME SAMPLE NO.:	NP-4	DATE RECEIVED	
CLIENT:	US Energy	TYPE OF SAMPLE	
CLIENT SAMPLE NO.:	NP-4		
SOIL DESCRIPTION:	Weak red clay w/ white clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	95.6%
3/8"	9.5200	95.6%
NO. 4	4.7600	95.6%
NO.10	2.0000	93.4%
NO. 16	1.1900	92.5%
NO. 30	0.5900	91.8%
NO. 50	0.2970	91.0%
NO. 100	0.1490	89.1%
NO. 200	0.0740	82.8%
	0.0287	74.0%
	0.0187	67.7%
Hydrometer	0.0111	61.3%
Range	0.0079	58.3%
	0.0057	52.0%
	0.0029	43.5%
	0.0012	34.4%

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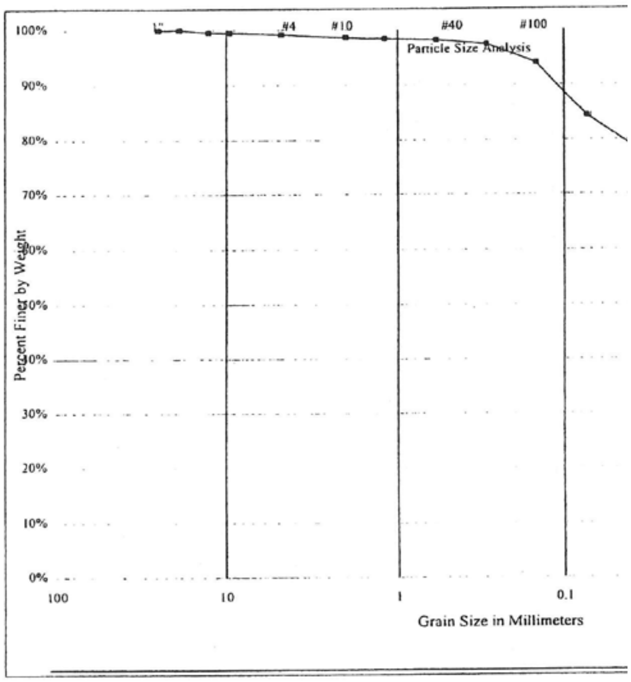
TABLE C-12. Gradation Results for Clay Sample C4

SIEVE & HYDROMETER TEST AST

IME SAMPLE NO.: C-4
CLIENT: US Energy
CLIENT SAMPLE NO.: C-4
SOIL DESCRIPTION: Weak red clay w/ white clay

DATE RECEIVED
TYPE OF SAMPL



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	99.5%
3/8"	9.5200	99.5%
NO. 4	4.7600	99.1%
NO.10	2.0000	98.6%
NO. 16	1.1900	98.4%
NO. 30	0.5900	98.1%
NO. 50	0.2970	97.4%
NO. 100	0.1490	94.0%
NO. 200	0.0740	84.4%
Hydrometer Range	0.0285	75.7%
	0.0184	70.8%
	0.0108	65.8%
	0.0078	62.4%
	0.0055	59.3%
	0.0029	48.1%
	0.0012	35.8%

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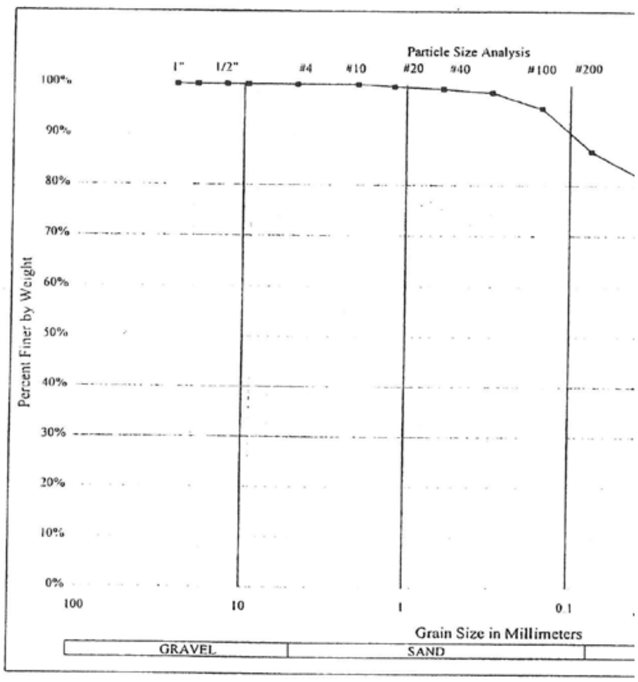
TABLE C-13. Gradation Results for Clay Sample DA1

SIEVE & HYDROMETER TEST AST

IME SAMPLE NO.:	Dam 1	DATE RECEIVED	
CLIENT:	US Energy	TYPE OF SAMPLE	
CLIENT SAMPLE NO.:	Dam 1		
SOIL DESCRIPTION:	Weak red clay w/ white clay		



Sieve Size	PARTICLE SIZE (mm)	PERCENT FINER
1"	25.4000	100.0%
3/4"	19.1000	100.0%
1/2"	12.7000	100.0%
3/8"	9.5200	100.0%
NO. 4	4.7600	100.0%
NO. 10	2.0000	100.0%
NO. 16	1.1900	99.5%
NO. 30	0.5900	99.1%
NO. 50	0.2970	98.4%
NO. 100	0.1490	95.3%
NO. 200	0.0740	86.7%
Hydrometer Range	0.0285	79.6%
	0.0184	74.5%
	0.0108	69.6%
	0.0078	64.6%
	0.0056	61.3%
	0.0029	50.0%
	0.0012	40.5%

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TABLE C-14. SOIL PROPERTIES FOR CLAY SAMI
NP6, NP10, NP11, WP4, AND C4

Sample	Liquid Limit	Plastic Limit	Plasticity Index
DA1	76	25	51
NP4	73	21	52
NP6	95	29	66
NP11	79	31	48
NP10	76	26	50
WP4	90	30	60
C4	73	29	44

Note: Results from Inber-Miller letter dated September ´

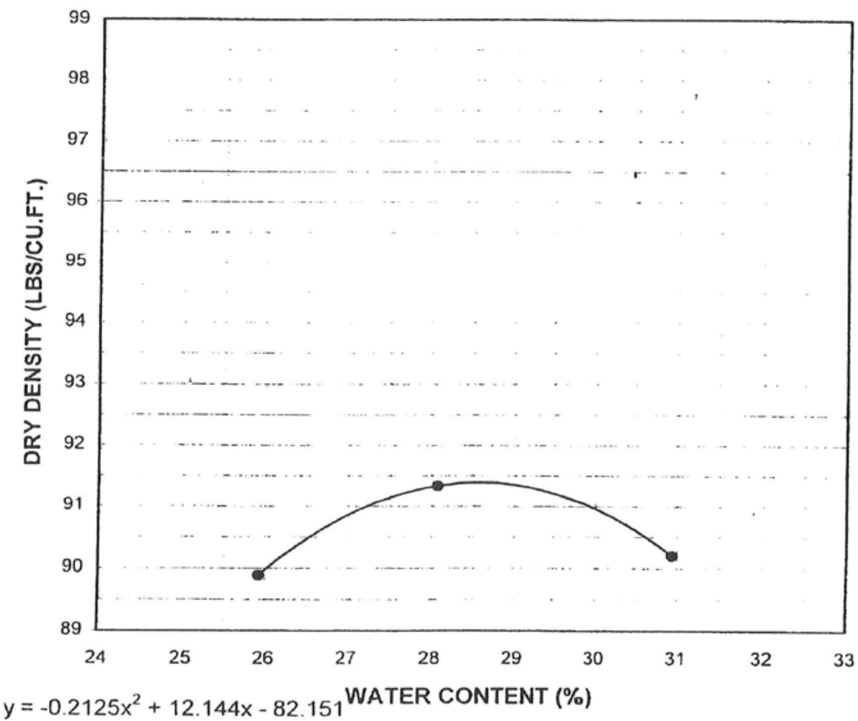
TABLE C-15. Moisture Density Analysis for NP11

MOISTURE-DENSITY ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon
JOB NO. 10223 RM
TEST DATE: 7-8-02
SOURCE: On-site
DESCRIPTION: Weak red clay

SAMPLE NO.: NP-11
SAMPLED BY: Client
TESTED BY : JPM
TEST METHOD: ASTM D 698-method A



$y = -0.2125x^2 + 12.144x - 82.151$

OPTIMUM WATER CONTENT (%):	28.6
MAXIMUM DRY DEN. (LBS/CU. FT):	91.4

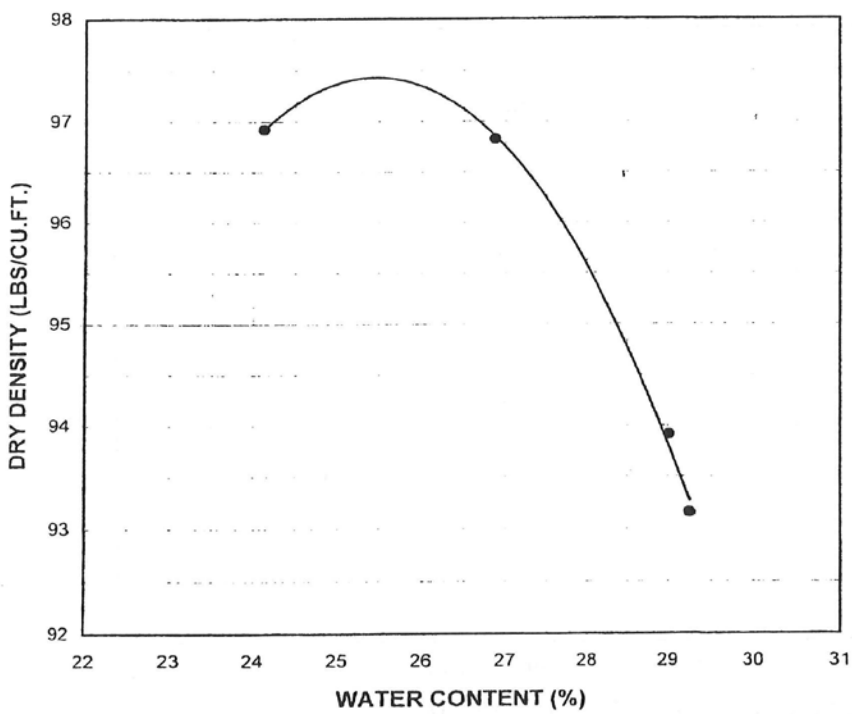
TABLE C-16. Moisture Density Analysis for NP10

MOISTURE-DENSITY ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon
JOB NO. 10223 RM
TEST DATE: 7-1-02
SOURCE: On-site
DESCRIPTION: Weak red clay

SAMPLE NO.: NP-10
SAMPLED BY: Client
TESTED BY : TGE
TEST METHOD: ASTM D 698-method A



OPTIMUM WATER CONTENT (%):	25.4
MAXIMUM DRY DEN. (LBS/CU. FT):	97.4

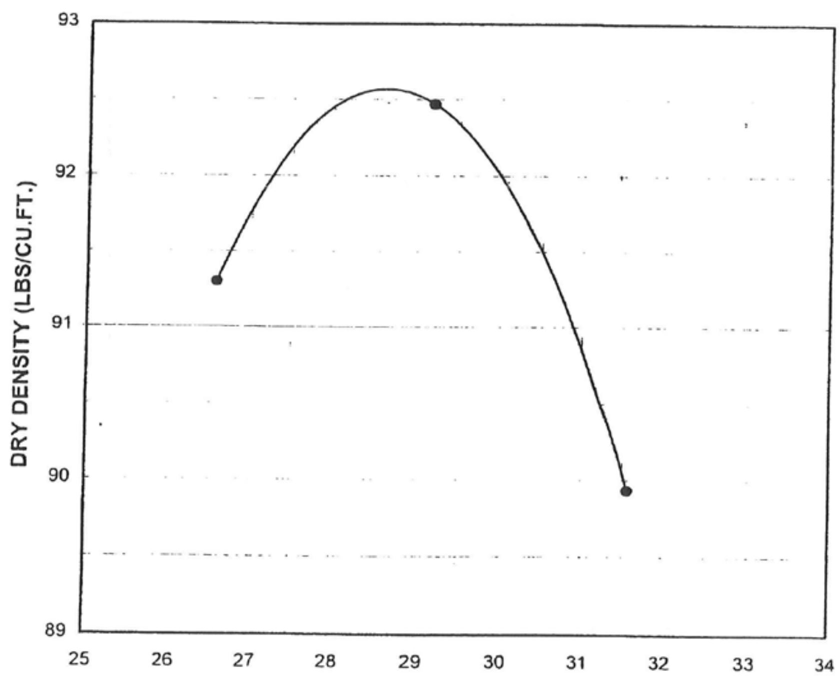
TABLE C-17. Moisture Density Analysis for NP6

MOISTURE-DENSITY ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon
JOB NO. 10223 RM
TEST DATE: 7-3-02
SOURCE: On-site
DESCRIPTION: Weak red clay

SAMPLE NO.: NP-6
SAMPLED BY: Client
TESTED BY : TGE
TEST METHOD: ASTM D 698-method A



$y = -0.3036x^2 + 17.378x - 156.11$

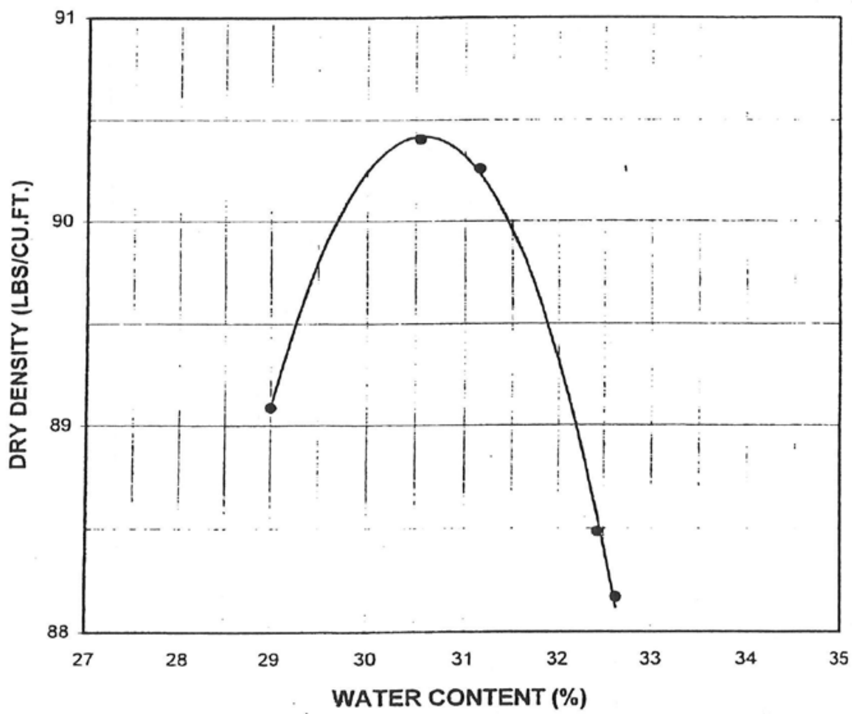
OPTIMUM WATER CONTENT (%):	28.6
MAXIMUM DRY DEN. (LBS/CU. FT):	92.5

TABLE C-18. Moisture Density Analysis for C4

MOISTURE-DENSITY ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT:	U.S. Energy	SAMPLE NO.:	C-4
PROJECT:	Shootering Canyon	SAMPLED BY:	Client
JOB NO.	10223 RM	TESTED BY :	TGE
TEST DATE:	8-15-02	TEST METHOD:	ASTM D 698-method A
SOURCE:	On-site		
DESCRIPTION:	Weak red clay		



OPTIMUM WATER CONTENT (%): 30.8
MAXIMUM DRY DEN. (LBS/CU. FT): 90.4

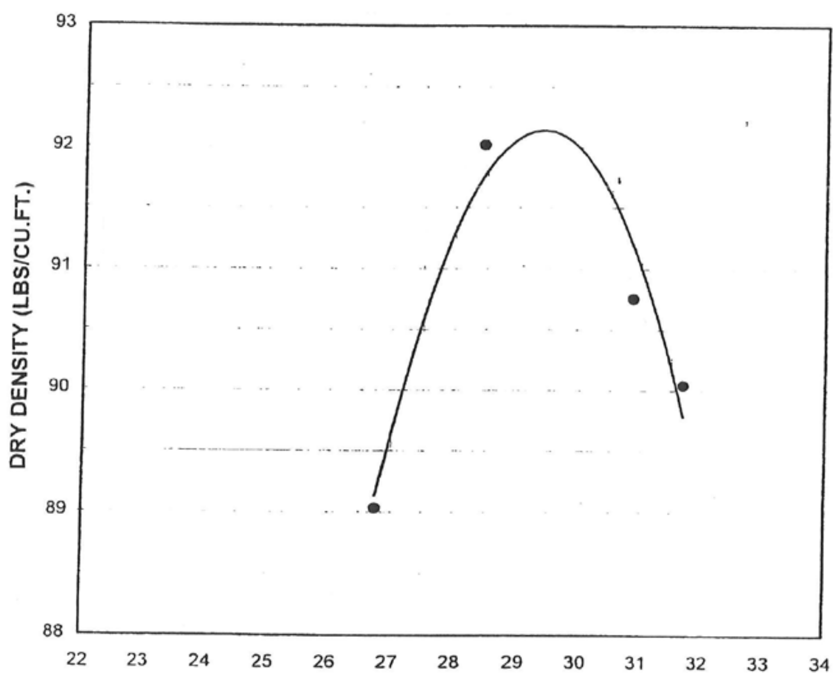
TABLE C-19. Moisture Density Analysis for DA1

MOISTURE-DENSITY ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon
JOB NO. 10223 RM
TEST DATE: 7-3-02
SOURCE: On-site
DESCRIPTION: Weak red clay

SAMPLE NO.: Dam 1-Clay
SAMPLED BY: Client
TESTED BY : TGE
TEST METHOD: ASTM D 698-method A



$y = -0.4384x^2 + 25.76x - 286.3$

OPTIMUM WATER CONTENT (%): 29.4
MAXIMUM DRY DEN. (LBS/CU. FT): 92.1

C.3 Soil Cover Physical Properties

Two gradations were performed on samples of the soil cover. Figures C-9 and C-10 present the results of the gradations performed on samples RSCI and RSC2, respectively. Both RSCI and RSC2 were taken from the soil cover placed in the north cell.

C.4 Rock Physical Properties

Gradations were performed on rock samples from the quarry area and the face of the Shootaring Canyon Dam. Rock durability analysis were also performed on the rock from the quarry, the dam face, as well as the rock soil cover material. Figures C-11, C-12, and C-13 present the results of the gradations of quarry samples QUI, QU2, and QU3, respectively. A gradation was also performed on the fines from sample QU3. The results of this test are presented on Table C-20. The results for the gradation on dam rock sample DSl are presented in Figure C-14. The results for the gradation on dam rock sample DS2 are presented in Figure C-15.

Rock durability analyses were performed on a rock sample from each of the potential sources; the quarry, the dam face, and the rock soil cover. The results of these durability tests are presented in Table C-21. Table C-22 presents rock durability tests that were conducted in 1997 which yield similar results. Petrographic analysis results are presented in Table C-23.

TABLE C-20. Gradation Results for QU-3 Sand

INBERG-MILLER ENGINEERS

PARTICLE SIZE ANALYSIS

CLIENT:	U.S. Energy
PROJECT:	Shootering Canyon
JOB NO.:	10223RM
TEST DATE:	6-18-02
TESTED BY	TGE
TEST METHOD	ASTM D422
SAMPLE NO.:	QU-3 Sand
SAMPLED BY:	Client
SOURCE:	On-site
SAMPLE DESCRIPTION:	Reddish silty fine sand
DESCRIPTION CONT.:	
GRADATION DESCRIPTION	

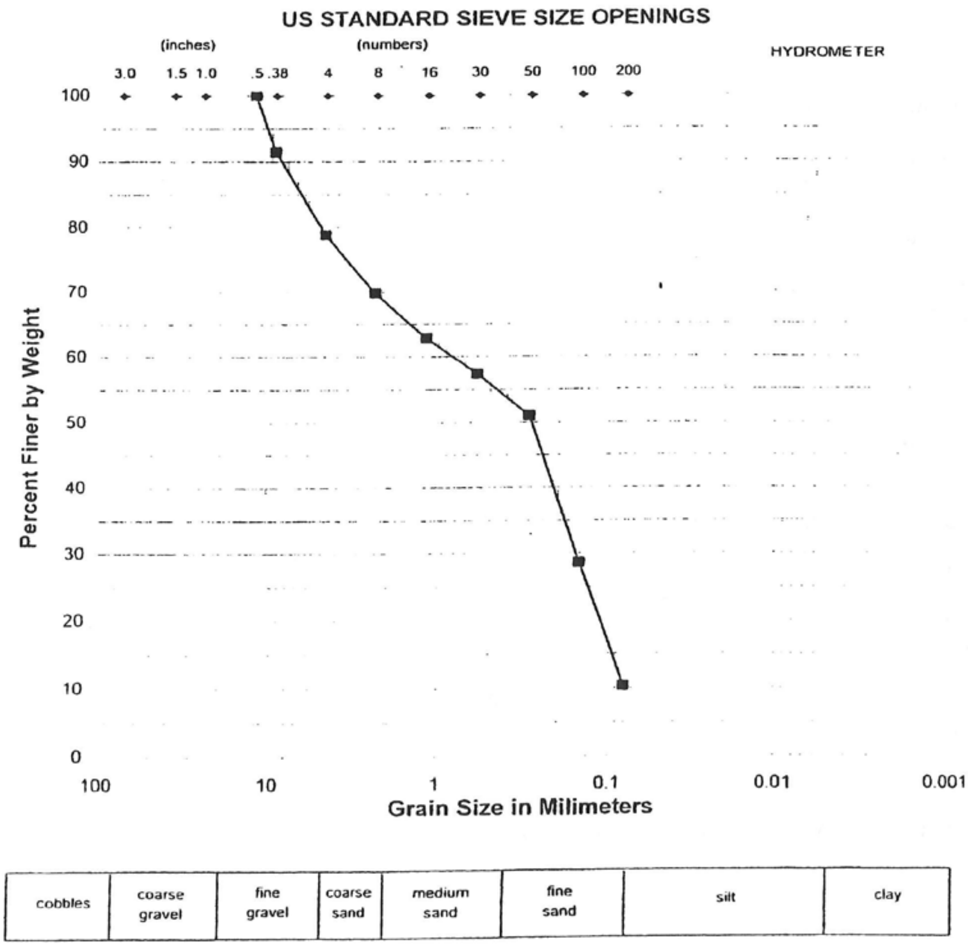
Sieve No.	Sieve Size (mm)	Wt. Retained (g)	Percent Retained	Percent Finer	Gradation Envelope Limits Lower	Upper
6.0	152.40					
5.0	127.00					
4.0	101.60					
3.5	88.90					
3.0	76.20					
2.5	63.50					
2.0	50.80					
1.5	38.10					
1.0	25.40					
0.75	19.05					
0.50	12.70	0.00	0.00	100.00		
0.375	9.53	41.75	8.54	91.46		
4	4.75	61.78	12.64	78.82		
8	2.36	44 07	9.02	69.81		
10	2.00					
16	1.18	34.09	6.97	62.83		
30	0.60	26.75	5.47	57.36		
40	0.43					
50	0.30	31.16	6.37	50.99		
100	0.15	109.45	22.39	28.60		
200	0.08	89.45	18.30	10.30		

TABLE C-20. Gradation Results for QU-3 Sand (continued)

PARTICLE SIZE ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT:	U.S. Energy	SAMPLE NO.:	QU-3 Sand
PROJECT:	Shootering Canyon	SAMPLED BY:	Client
JOB NO.:	10223RM	SOURCE:	On-site
TEST DATE:	6-18-02	SAMPLE DESCRIPTION:	Reddish silty fine sand with some gravel
TESTED BY:	TGE		
TEST METHOD:	ASTM C136	GRADATION DESCRIPTION:	



Unified Soil Classification System (ASTM D2487)

TABLE C-21. ROCK DURABILITY TEST RESULTS, JUNE 2002

Loss LA Abrasion, Specific Gravity and Absorption Results

Sample Identification	% Loss LA Abrasion	Apparent Sp. G.	Bulk Sp. G.	Bulk SSD Sp.G.	Absoption %	Composite Sodium Sulphate Soundness % Loss
QU - Igneous	3.7	2.638	2.532	2.572	1.6	1.90
QU - Sandstone	5.1	2.579	2.445	2.497	2.13	4.35
RSC - Igneous	5.5	2.615	2.475	2.528	2.16	8.45
RSC - Sandstone	9.9	2.542	2.356	2.429	3.1	13.50
DS - Igneous	3.9	2.637	2.529	2.57	1.63	4.20
DS - Sandstone	7.7	2.528	2.392	2.446	2.25	12.85

Sodium Sulfate Soundness Tests

Sample Identification	1-1/2" to 2" Percent Loss	2" to 2-1/2" Percent Loss
QU - Igneous	1.7	2.1
QU - Sandstone	3	5.7
RSC - Igneous	12	4.9
RSC - Sandstone	12.3	14.7
DS - Igneous	1.1	7.3
DS - Sandstone	12.3	13.4

Rock Proportions in Samples

Sample Identification	Percentage Igneous	Percentage Sandstone	Size Range
QU1	42	58	2"-5"
QU2	32	68	3"-5"
QU3	31	69	2"-8"
DS1	34	66	2"-6"
DS2	39	61	2"-5.5"
RSC1	41	59	2"-6.5"
RSC2	31	69	2"-5.5"

Note: Results from Inber-Miller letter dated September 17, 2002

TABLE C-22. Rock Durability Test Results April, 1997

ROCK DURABILITY TEST RESULTS
U.S. Energy Shootering
Canyon, Utah IME Job
No. 7664-RM April 4,
1997

Test	Tan Sandstone	Igneous Rock
Los Angeles Abrasion - % Loss [1]	7.8	2.3
Apparent Bulk Specific Gravity	2.556	2.676
Bulk Specific Gravity	2.409	2.548
SSD Bulk Specific Gravity	2.467	2.596
Absorption (%)	2.39	1.88
$NaS0_4$ Soundness[2] % Loss 27'2 to 2"	5.29	1.37
$NaS0_4$ Soundness[2] %Loss 2" to 1-112"	3.44	0.98
$NaS0_4$ Soundness[2] % Loss 1-112" to **1"**	2.22	2.25
$NaS0_4$ Soundness[2] % Loss **1"** to 3/4"	14.55	5.94
$NaS0_4$ Soundness[2] % Loss 3/4" to 112"	13.75	4.41
$NaS0_4$ Soundness[2] % Loss 112" to 3/8"	24.96	8.60
$NaS0_4$ Soundness[2] % Loss 3/8" to #4	16.74	9.39
Rebound No.	43	52

Notes:

1. Modified for 100 revolutions
2. Actual percent loss- not weighted for "original gradation." requested, $NaS0_4$ Soundness samples were crushed to generate sufficient material of practical test Size.

TABLE C-23. Petrographic Analysis of Erosion Protection Rocks

THEODORE P. PASTER, Ph.D.
Consultant
11425 East Cimmarron Drive
Englewood, Colorado 80111
(303) 771-8219

August 19, 2002

Thomas G. Michel
Hydro-Engineering, LLC
4685 South Magnolia
Casper, WY 826042

RE: Petrographic Analyses of Andesite and Sandstone to be Used as Erosion Protection for a Reclaimed Uranium Tailings Facility.

SUMMARY

The petrographic analyses of the two rock types in the riprap source yields the following parameters:

ROCK NAME	NRC GROUP (Table 6.1)	EXPANDABLE SMECTITE CONTENT
Andesite porphyry & Porphyritic andesite	2	Nil
Fine-grained sandstone	? (parameters not in Table 6.1)	Nil

The minimum fracture spacing is estimated to be greater than 2" to 4" based on the particles sizes. The particles are equant and rounded with no weathering rinds.

Respectfully submitted:

INTRODUCTION

An aggregate source in Utah is petrographically analyzed for a source of erosion protection rock mulch or riprap to be used in a reclaimed uranium tailings facility.

The aggregate is characterized by two primary rock types:
1) An andesite porphyry and porphyritic andesite.
2) A fine-grained porous sandstone.

PETROGRAPHIC ANALYSES

Megascopic Description of Andesite

Six andesite samples were received. They are rounded particles measuring 2" to 3" in average diameter and contain no visible weathering rind when broken open. Samples 1a, 1b and 1c are andesite porphyry containing more than 50% phenocrysts of plagioclase (Pl) and hornblende (Hb). Samples 1d, 1e and 1f are porphyritic andesites containing less than 50% phenocrysts of Pl and Hb. Two particles of each type of andesite were sectioned for petrographic analysis and the measured percentages of the four samples are given in **TABLE 1**.

TABLE 1
MINERAL PERCENTAGES IN FOUR ANDESITE SAMPLES
UTAH RIPRAP

Sample No.

	QU-1a		QU-1c		QU-1d		QU-1e	
Phase	cts	%	cts	%	cts	%	cts	%
Groundmass	209	43.4 ±4.5	254	41.1 ±4.0	346	59.6 ±4.1	265	45.4 ±4.1
Plagioclase(Pl)	98	20.3 ±3.7	180	29.1 ±3.7	61	10.5 ±2.5	116	19.8 ±3.3
Carbonate inPl	22	4.6 ±1.9	11	1.8 ±1.1	5	0.9 ±0.8	47	8.0 ±2.2
" in HB	33	6.8 ±2.3	30	4.9 ±1.7	12	2.1 ±1.2	33	5.6 ±1.9
Goethite	0	0	0	0	49	8.4 ±2.3	0	0
Kaolinite	35	7.3 ±2.4	1	0.2 ±0.2	0	0	0	0
Chlorite	38	7.9 ±2.5	56	9.1 ±2.3	8	1.4 ±1.0	18	3.1 ±1.4
Magnetite	5	1.0 ±0.9	5	0.8 ±0.7	4	0.7 ±0.7	14	2.4 ±1.3
Vnlts/Fracs*	2	0.4 ±0.4	0	0	2	0.3 ±0.3	tr	tr
Ht/Lx**	12	2.5 ±1.4	10	1.6 ±1.0	11	1.9 ±1.1	7	1.2 ±0.9
Apatite	1	0.2 ±0.2	0	0	1	0.2 ±0.2	2	0.3 ±0.3
Illite	7	1.5 ±1.1	42	6.8 ±2.0	17	2.9 ±1.4	8	1.4 ±1.0
Pores in gdms	5	1.0 ±0.9	0	0	57	9.8 ±2.5	6	1.0 ±0.8
Voids,Fracs/Ves	11	2.3 ±1.4	7	1.1 ±0.8	4	0.7 ±0.7	5	0.9 ±0.8
Biotite	3	0.6 ±0.6	1	0.2 ±0.2	1	0.2 ±0.2	0	0
Sphene/Rutile	0	0	2	0.3 ±0.3	0	0	0	0
Quartz	1	0.2 ±0.2	6	1.0 ±0.8	0	0	5	0.9 ±0.8
Carb in gdms***	0	0	4	0.6 ±0.6	1	0.2 ±0.2	23	3.9 ±1.6
Carb in Ves****	0	0	9	1.4 ±0.9	1	0.2 ±0.2	2	0.3 ±0.3
Gdms, pore-free	0	0	0	0	0	0	30	5.1 ±1.8
Quartz Phenos	0	0	0	0	0	0	4	0.7 ±0.7
Totals	482	100.0	618	100.0	580	100.0	585	100.0

Legend:
Vnlts/Fracs* = Veinlets/Fractures
Ht/Lx** = Hematite/Leucoxene
Carb in gdms*** = Carbonate
Carb in Ves**** = Carbonate in Vesicles

The phenocrysts of Pl are up to 6 mm in size in the andesite porphyry and up to 14 mm in size in the porphyritic andesite samples.

Microscopic Description of Andesite
Due to deuteric or low grade metasomatism (Not weathering.) the phenocrysts are replaced by secondary minerals as shown in **TABLE 2.**

TABLE 2
SECONDARY MINERALOGY OF PLAGIOCLASE AND HORNBLENDE IN UTAH ANDESITE

Phenocryst	Constituent Minerals* Sample: 1a	1c	1d	1e
Pl = Pl + Pl Carb + Kaol + Ill**	34.0	37.9	14.3	29.2
Hb = Hb Carb + Chl + Ht/Lx + Q**	15.6	15.6	13.8	10.8

Legend:
* = from Table 1.
**: Pl = plagioclase
Pl Carb = Carbonate in Pl.
Kaol = kaolinite
Ill = illite
Hb Carb = Carbonate in hornblende.
Chl = chlorite
Ht/Lx = hematite and leucoxene
Q = quartz
Hb = hornblende

Note that the Hb is totally altered leaving only relict outlines of the original phenos.

Andesite Rating
The group in Table 6.1 of Nelson et al.* into which the andesite would fit is 2.

Fractures in Andesite
The fractures trend in one direction in samples a and d and more than 1 direction in e. The density of fractures more than 4 mm long are listed in **TABLE 3.**

TABLE 3
FRACTURE DENSITY IN ANDESITE SECTIONS
(Fractures larger than 4 mm.)

Sample No.	Avg fracture spacing (in mm)
QU - 1a	3
QU - 1c	>22
QU - 1d	8
QU - 1e	17

Evidently the through-going fractures that determine particle size are spaced 2" to 3" as judged by the particle sizes.

* = 1986; Nelson, J.D. et al.; Methodology for Evaluating Long Term Stabilization Designs of Uranium Mill Tailings Impoundments; NUREG/CR-4620.

TABLE C-23. Petrographic Analysis of Erosion Protection Rocks (continued)

Clays in Andesite
The clay and clay-size minerals identified in the andesite are kaolinite, illite and chlorite as shown in **TABLE 1**.

X-ray diffraction on QU-1c confirmed the presence of kaolinite and chlorite and no detectable smectite. Based on the x-ray and sample parameters the detection limit is 0.3% of the sampl

Megascopic Description of Sandstone
Six sandstone samples were received. They measure 2" to 4" average diameter with no weathering rinds and are rounded to broken with sharp edges. They are briefly described below in three types:

Sample No.	Description
QU-S_1	Thinly laminated (1-4mm thick laminae) shown by reddish-brown Fe-staining, fine-grained sandston Grayish-orange**. Also contains 4-9mm thick cross-bedded layers.
QU-S_2, S_4	Fine-grained sandstone is a very pale orange col with ≤ 1mm Fe-oxide stained blebs. Non-laminated
QU-S_3, S_5, S_6	Fine-grained, very pale orange** sandstone with little or no iron staining and no laminae.

* = Average grain size is 0.1 to 0.2mm. Fine sand size is 0.06mm to 0.2mm.
**= Color on Geological Society of America Rock Color Chart, 1991.

Microscopic Description of Sandstone
The mineralogical components of the sandstone are given in **TAB 4** and **APPENDIX I**.

TABLE 4
MINERAL PERCENTAGES IN THREE SANDSTONE SAMPLES
UTAH RIPRAP

	Sample No.					
	QU-1a		QU-1c		QU-1d	
Phase	cts	%	cts	%	cts	%
Clasts:						
Q + K-Spar*	440	69.7	491	75.3	444	76.0
Microcline	7	1.1	14	2.1	17	2.9
Other	1	0.1	0	0	3	0.5
Interstitial voids:	149	23.6	74	11.4	99	17.0
Cement:						
Carbonate	1	0.2	37	5.7	4	0.7
Clay	8	1.3	8	1.2	16	2.7
Goethite	25	4.0	27	4.1	1	0.2
Fracture:	0	0	1	0.2	0	0
Totals	631	100.0	651	100.0	584	100.0

Legend:
Q + K-Spar = Quartz + Orthoclase

TABLE C-23. Petrographic Analysis of Erosion Protection Rocks (continued)

The average clast percentage is approximately 76%, pore space is 17% and cement is 7%. The cement is composed of goethite, carbonate and clay.

Sandstone Rating

The references at hand and information supplied by Hydro-Engineering are not complete enough to rate the sandstone.

Fractures in Sandstone

No fractures were seen in thin section. Joints/fractures comprise some surfaces of the particles and these are estimated to be greater than 2" spacing.

Clay in Sandstone

The total clay content of the sandstone is estimated to be less than 2.&% and average 1.7%. No expandable smectite was found by x-ray diffraction. The limit is 0.2% of the sample.

August 19, 2002

APPENDIX I
PETROGRAPHIC DESCRIPTIONS

QU-1a; Andesite Porphyry

Phenos (52.6%):

34.0% Plagioclase (Pl, An_{16})	0.06-6.0mm	Oligoclase centers. Euhedra with oscillatory zoning. 8-90% replaced with carbonate, illite and kaolinite. Alteration is generally in layers corresponding to compositional zoning.
17.4% [Hornblende] (Hb)	<0.08-3.6mm	Relict euhedra. 100% replaced by chlorite >carbonate. Contains inclusions of hematite (Ht) + leucoxene (Lx). Occasionally partly replaced by quartz (Q).
1.0% Magnetite (Mt)	<0.04-0.3mm	Eu-anhedra. Partly replaced by Ht/Lx. Notably in relict Hb.
0.2% Apatite	0.05-0.15mm	Stubby prisms.

Groundmass (43.4%):

43.4% Feldspar(F)/Ferromagnesian(FM)	<0.01-0.01mm	Indistinctly bounded anhedral patches of incipient, sub-variolitic inter-growths of F and FM.

Fractures (0.4%):

0.4% Carbonate	0.04mm thick 0.04x<1.0mm	Anhedral blebs in groundmass that are probably relict FM.

Illite is approximately 1.5 % of rock

No weathering rinds.

Alteration is late stage metasomatism common in volcanic rocks. The metasomatism is propylitic/deuteric that has altered the Hb and partially altered the Pl and Mt.

QU-S; Medium-Grained, Quartz Sandstone with Little Cement.

Clastics (79.4%):

76.0% Quartz(Q)> Orthoclase(K-Spar)	0.05-0.3mm	Equant clastics. Rounded in voids and and straight edges where in contact due to load compression.
2.9% Microcline	0.12-0.35mm	Same description as Q and K-Spar.
0.5% Other	<0.01-0.06mm	Predominately eu-subhedral rutile and chert. Very rare volcanic (andesite?).

TABLE C-23. Petrographic Analysis of Erosion Protection Rocks (continued)

Interstices (20.6%):

17.0% Voids	<0.01-0.3mm	Irregular shapes interstitial to clastics.
2.&% Clay	<<0.01mm	In ragged clumps or dispersed in voids.
0.7% Carbonate	<0.01mm	Subhedral in aggregates.
0.2% Goethite	<0.01-0.12mm	Predominately anhedra to euhedra.

C.5 Entrada Sand Physical Properties

Gradations were performed on three samples of the Entrada Sandstone at the site. The gmdation results for samples CV4, NPlO, and NP6 are presented in Tables C-24, C-25, and C-26, respectively. Sample CV4 was taken from the cross valley berm at a depth of 1.5' to 2.5'. Samples NP10 and NP6 were taken from the red sand in backhoe pits in the north cell.

TABLE C-24. Gradation Results for Entrada Sand CV4, 1.5' – 2.5'

ENERGY LABORATORIES, INC. • 2393 SaH Creek Highway (82601) • P.O Box 3258 • Casper; WY 82602
Toi/Free 888.23S.0515 • 307.2350515 · Fax 307.234.1639 • casper@energylab.com • www.energylab.com

LABORATORY ANALYTICAL REPORT

Client:	US Energy	Report Date:	07/08/02
Project:	Uranium One Americas Shootaring Canyon	Collec:fion Date:	06/04/02
		Date Received:	06/10/02
Lab ID:	C02060335-0ll	Matrix:	SOIL
Client Sample ID:	CV4 1.5-2.5		

Analyses	Result	Units	Qual	RL	MCLI QCL	Method	Analysis Date / By
PHYSICAl PROPERTIES							
Moisture	1.8	%		0.1		USOA26	06/12102 10:27 / vh
RAOIONUCUOES- TOTAL							
Radium226	0.2	pCi / g-<lry		0.1		E903.0	06/27/02 04:31 / rs
Radium 226 precision	0.1	±				E903.0,	06/27/02 04:31/ rs
Thorium230	0.3	pCi / g..<fry		0.1		E907.0	06/21/02 10:30 / ph
Thorium 230 precision	0	:!:				E907.0	06/21/02 10:30 / ph
Uranium	2.75	mglkg-dry		0.02		SW6020	06/23102 03:16/ smd
SIEVES							
0.125 Inch Sieve, Passed	99.9	%		1.0		ASA15-2	06/26102 07:00 / lmh
0.1251nch Sieve. Retaine<l	NO	%		1.0		ASA15-2	06126102 07:00 / lmh
0.185 Inch Sieve. Passed	99.9	%		1.0		ASA15-2	06/26102 07:00 / lmh
0.185 Inch Sieve, Retained	NO	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 12 Sieve. Passed	99.7	%		1.0		ASA15-2	06126/02 07:00 / lmh
No. 12 Sieve. Retaine<l	NO	%		1.0		ASA15-2	06126/02 07:00 / lmh
No. 20 Sieve, Passed	99.2	%		1.0		ASA15-2	06126/02 07:00 / lmh
No. 20 Sieve. Retaine<l	NO	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 60 Sieve, Passed	79.9	%		1.0		ASA15-2	06126/02 07:00 / lmh
No. 60 Sieve, Retained	19.3	%		1.0		ASA15-2	06126/02 07:00 / lmh
No. 100 Sieve. Passed	25.6	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 100 Sieve, Retained	54.3	%		1.0		ASA15-2	06126/02 07:00 / lmh
No. 200 Sieve. Passed	3.1	%		1.0		ASA15-2	06126102 07:00 / lmh
No. 200 Sieve. Retained	22.5	Yo		1.0		ASA15-2	06126102 07:00 / lmh

Report Definitions:
Rl- Analyte reporting limit.
QCl Quality control limit.
MCL - Maximum contammant level
NO - Noldetecte<l at the reporting limit.

INBERG-MILLER ENGINEERS

PARTICLE SIZE ANALYSIS

CLIENT:	U.S. Energy
PROJECT:	Shootering Canyon
JOB NO.:	10223RM
TEST DATE:	8-21-02
TESTED BY:	GLM
TEST METHOD:	ASTM D422
SAMPLE NO.:	NP-10 Sand
SAMPLED BY:	Client
SOURCE:	On-site
SAMPLE DESCRIPTION:	Reddish silty fine sand
DESCRIPTION CONT:	
GRADATION DESCRIPTION:	

Sieve No.	Sieve Size (mm)	Wt. Retained {g)	Percent Retained	Percent Finer	Gradation Envelope Limits Lower	Upper
6.0	152.40					
5.0	127.00					
4.0	101.60					
3.5	88.90					
3.0	76.20					
2.5	63.50					
2.0	50.80					
1.5	38.10					
1.0	25.40					
0.75	19.05					
0.50	12.70					
0.375	9.53					
4	4.75	0.00	0.00	100.00		
8	2.36	0.73	0.25	99.75		
10	2.00					
16	1.18	0.26	0.09	99.66		
30	0.60	0.26	0.09	99.57		
40	0.43					
50	0.30	7.14	2.47	97.10		
100	0.15	157.43	54.51	42.59		
200	0.08	96.70	33.48	9.11		

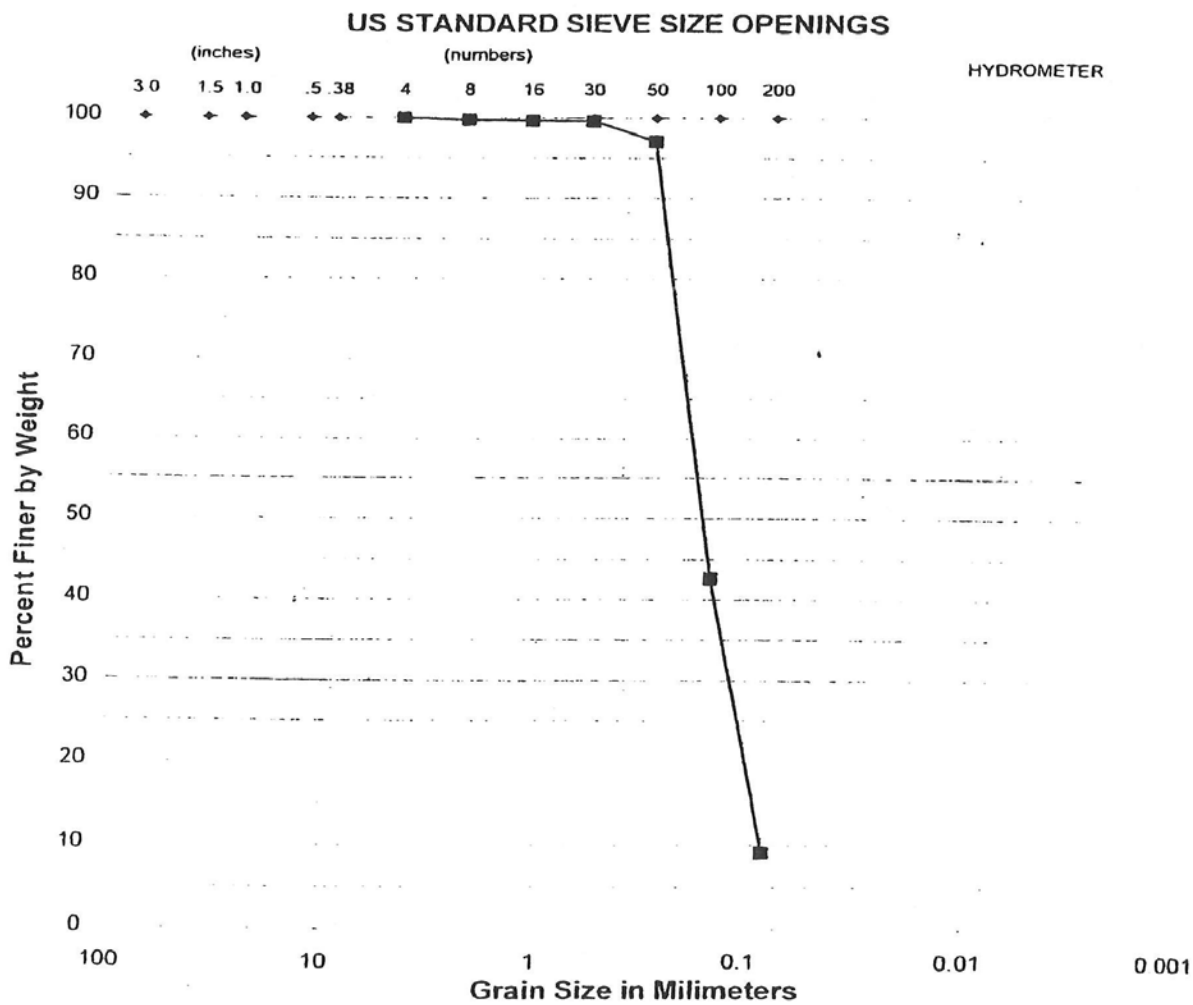
PARTICLE SIZE ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon
JOB NO.: 10223RM
TEST DATE: 8-21-02
TESTED BY: GLM
TEST METHOD: ASTM C136

SAMPLE NO.: NP-10 Sand
SAMPLED BY: Client
SOURCE: On-site
SAMPLE DESCRIPTION: Reddish silty fine sand

GRADATION DESCRIPTION:



cobbles	coarse gravel	fine gravel	coarse sand	medium sand	fine sand	silt	clay

Unified Soil Classification System (ASTM D2487)

INBERG-MILLER ENGINEERS

PARTICLE SIZE ANALYSIS

CLIENT:	U.S. Energy
PROJECT:	Shootering Canyon
JOB NO.	10223RM
TEST DATE:	8-21-02
TESTED BY	GLM
TEST METHOD:	ASTM D422
SAMPLE NO.:	NP-6 Sand
SAMPLED BY:	Client
SOURCE:	On-site
SAMPLE DESCRIPTION:	Reddish silty fine sand
DESCRIPTION CONT.:	
GRADATION DESCRIPTION:	

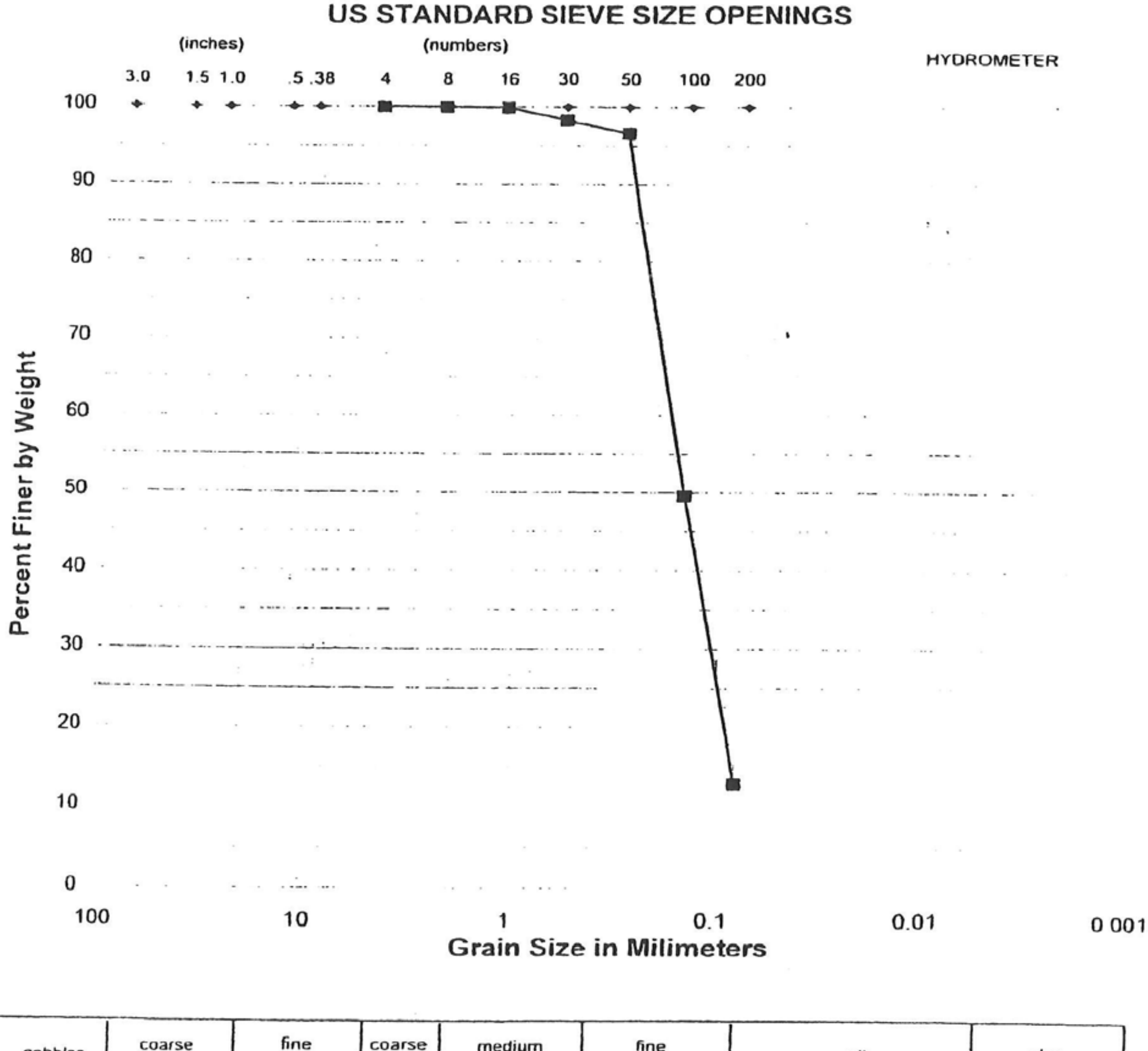
Sieve No.	Sieve Size (mm)	Wt. Retained (g)	Percent Retained	Percent Finer	Gradation Envelope Limits Lower	Upper
6.0	152.40					
5.0	127.00					
4.0	101.60					
3.5	88.90					
3.0	76.20					
2.5	63.50					
2.0	50.80					
1.5	38.10					
1.0	25.40					
0.75	19.05					
0.50	12.70					
0.375	9.53					
4	4.75	0.00	0.00	100.00		
8	2.36	0.05	0.02	99.98		
10	2.00					
16	1.18	0.20	0.08	99.90		
30	0.60	4.28	1.65	98.26		
40	0.43					
50	0.30	4.40	1.69	96.57		
100	0.15	122.33	47.05	49.52		
200	0.08	95.26	36.64	12.88		

PARTICLE SIZE ANALYSIS

INBERG-MILLER ENGINEERS

CLIENT: U.S. Energy
PROJECT: Shootering Canyon
JOB NO.: 10223RM
TEST DATE: 8-21-02
TESTED BY: GLM
TEST METHOD: ASTM C136

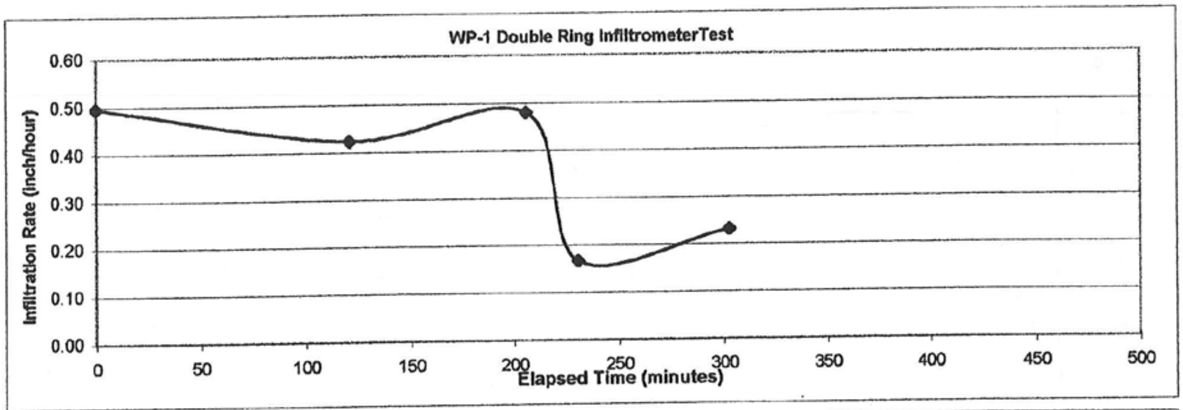
SAMPLE NO.: NP-6 Sand
SAMPLED BY: Client
SOURCE: On-site
SAMPLE DESCRIPTION: Reddish silty fine sand
GRADATION DESCRIPTION:

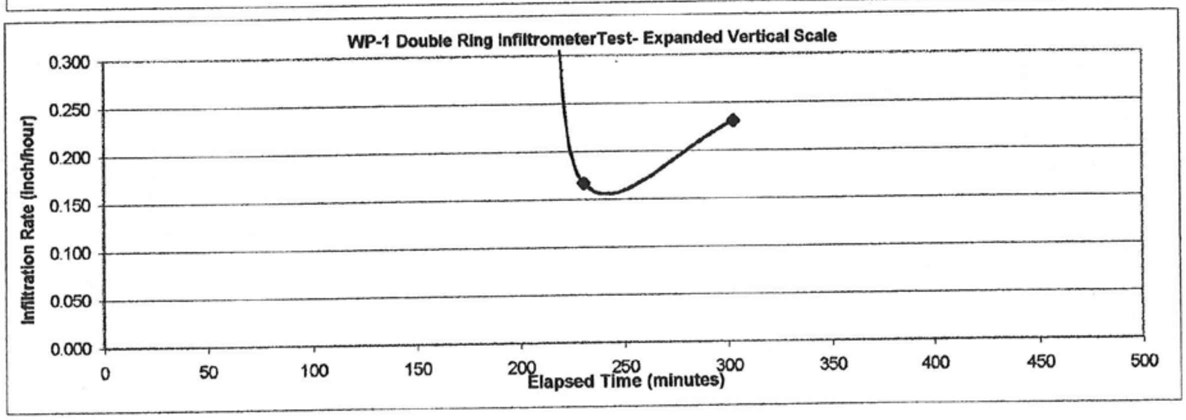


cobbles	coarse gravel	fine gravel	coarse sand	medium sand	fine sand	silt	clay

Unified Soil Classification System (ASTM D2487)

FIGURE C-1. INFILTROMETER TEST RESULTS FOR WP1



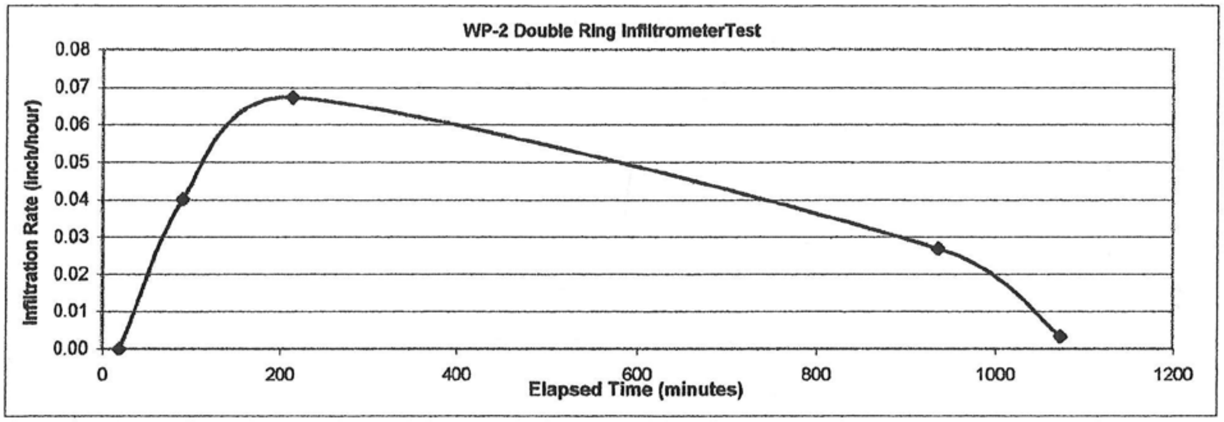


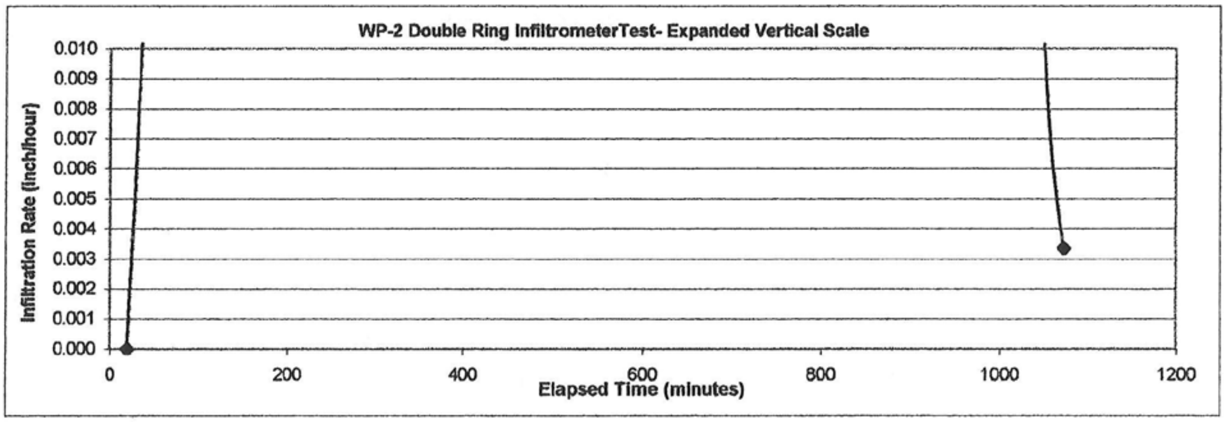
INFILTRATION TEST #1
ON CLAY IN BACKHOE PIT WP-1
INNER RING = 12-1/8" DIAMETER

DATE	TIME	VOLUME IN JUG (GAL.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INCREMENT VOLUME (GAL.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/3/02	11:21		FILLED OUTER RING					
	11:24		FIILLED INNER RING					
	11:45		HAVING PROBLEMS WITH GLUG JUG					
	11:48	2.75	0					
	13:49	2.25	121	121	0.5	**0.99191**	**0.49595**	**3.50E-04**
	15:14	1.95	206	85	0.3	**0.84721**	**0.42360**	**2.99E-04**
	15:36	1.85	231	25	0.1	**0.96017**	**0.48008**	**3.39E-04**
	16:51	1.75	303	72	0.1	**0.33339**	**0.16670**	**1.18E-04**
	19:01	1.5	433	130	0.25	**0.46162**	**0.23081**	**1.63E-04**
	19:10		REFILL INNER RING TO 2.3 GAL					
6/4/02	7:03		GLUG JUG FAILED OVER NIGHT 0.22' FROM TOP					
	9:29		0.22' FROM TOP					

*Note - The failure of the supply system rendered the test results unusable.
No average infiltration rate is calculated.

FIGURE C-2. INFILTROMETER TEST RESULTS FOR WP2



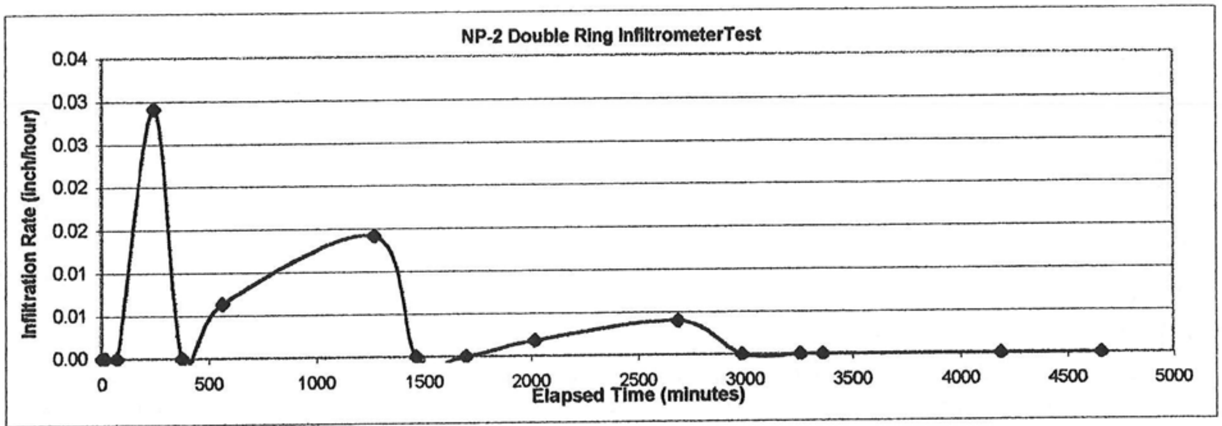


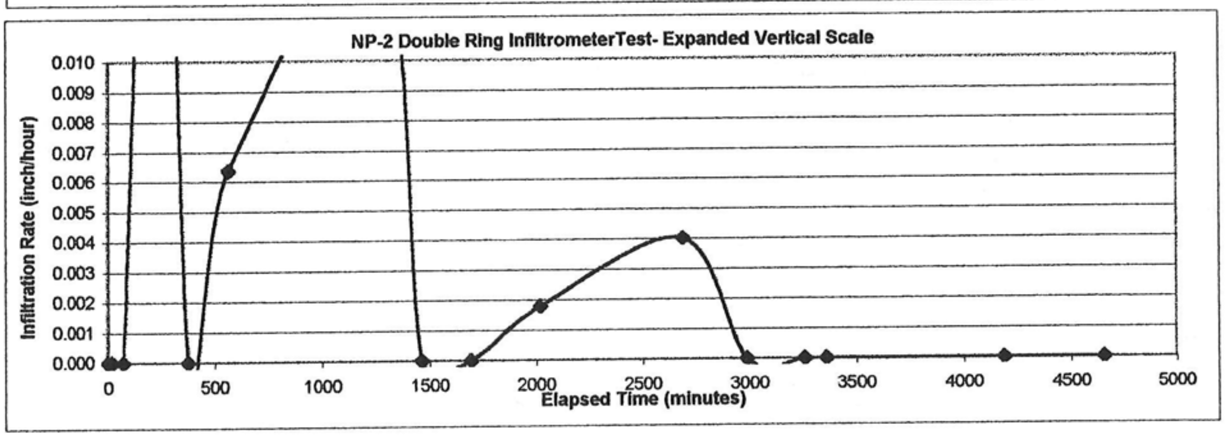
INFILTRATION TEST #2
ON CLAY IN BACKHOE PIT WP-2

DATE	TIME	DEPTH TO WATER IN INNER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/3/02	14:27			FILLED OUTER RING				
	14:39			FILLED INNER RING				
	15:06			HAVING PROBLEMS WITH GLUG JUG				
	15:10			HAVING PROBLEMS WITH GLUG JUG				
	15:20			HAVING PROBLEMS WITH GLUG JUG				
	15:24	0.415	0	0				
	15:44	0.415	0	20	20	**0.00000**	**0.00000**	0.00E+00
	16:54	0.42	0.005	90	70	**0.08000**	**0.04000**	2.82E-05
	18:58	0.44	0.02	214	124	**0.13458**	**0.06729**	4.75E-05
6/4/02	7:01	0.475	0.035	937	723	**0.05379**	**0.02689**	1.90E-05
	9:17	0.48	0.005	1073	136	**0.00671**	**0.00336**	2.37E-06

Average Infiltration Rate after 1000 minutes 0.00336 2.367E-06

FIGURE C-3. INFILTROMETER TEST RESULTS FOR NP2

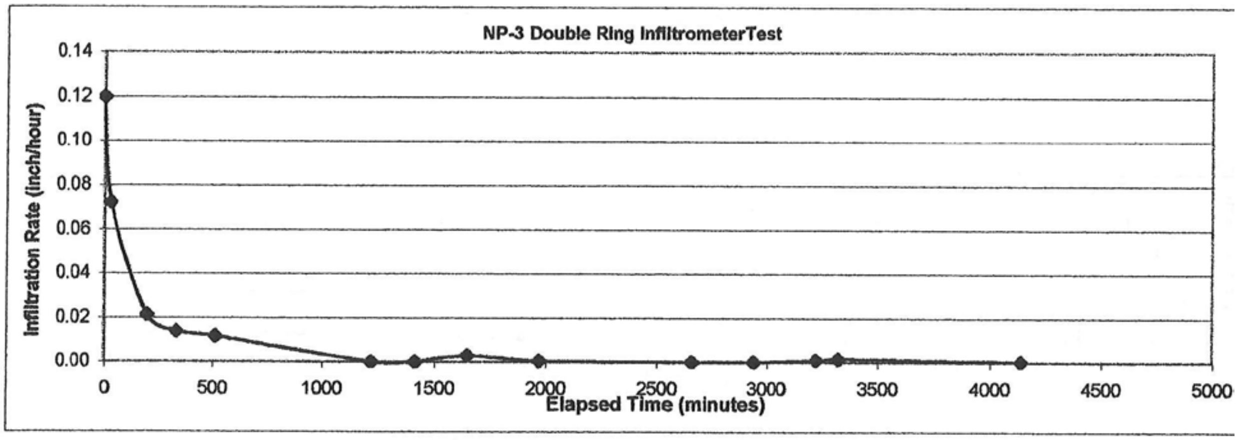


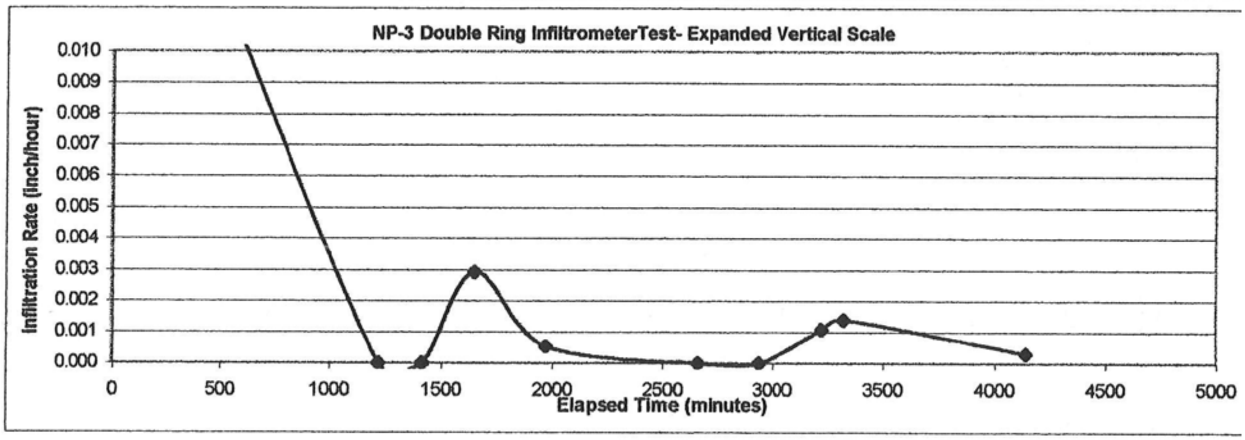


INFILTRATION TEST #3
ON CLAY IN BACKHOE PIT NP-2

DATE	TIME	DEPTH TO WATER IN INNER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/4/02	9:43			SETTING RINGS				
	9:50			FILLED OUTER RING				
	9:54			FILLED INNER RING				
	9:56	0.59	0	0				
	10:00	0.59	0	4	4	0.00000	0.00000	0.00E+00
	10:17	0.59	0	21	17	0.00000	0.00000	0.00E+00
	11:09	0.59	0	73	52	0.00000	0.00000	0.00E+00
	14:03	0.6	0.01	247	174	0.05830	0.02915	2.06E-05
	16:16	0.6	0	380	133	0.00000	0.00000	0.00E+00
	19:22	0.605	0.005	566	186	0.01272	0.00636	4.49E-06
6/5/02	7:08	0.63	0.025	1272	706	0.02830	0.01415	9.98E-06
	10:23	0.63	0	1467	195	0.00000	0.00000	0.00E+00
	14:15	0.63	0	1699	232	0.00000	0.00000	0.00E+00
	19:37	0.635	0.005	2021	322	0.00356	0.00178	1.26E-06
6/6/02	6:50	0.65	0.015	2694	673	0.00802	0.00401	2.83E-06
	11:48	0.65	0	2992	298	0.00000	0.00000	0.00E+00
	16:20	0.65	0	3264	272	0.00000	0.00000	0.00E+00
	18:01	0.65	0	3365	101	0.00000	0.00000	0.00E+00
6/7/02	7:48	0.65	0	4192.2	827.2	0.00000	0.00000	0.00E+00
	15:36	0.65	0	4660	467.8	0.00000	0.00000	0.00E+00
				Average Infiltration Rate after 1500 minutes			0.00072	5.107E-07

FIGURE C-4. INFILTROMETER TEST RESULTS FOR NP3

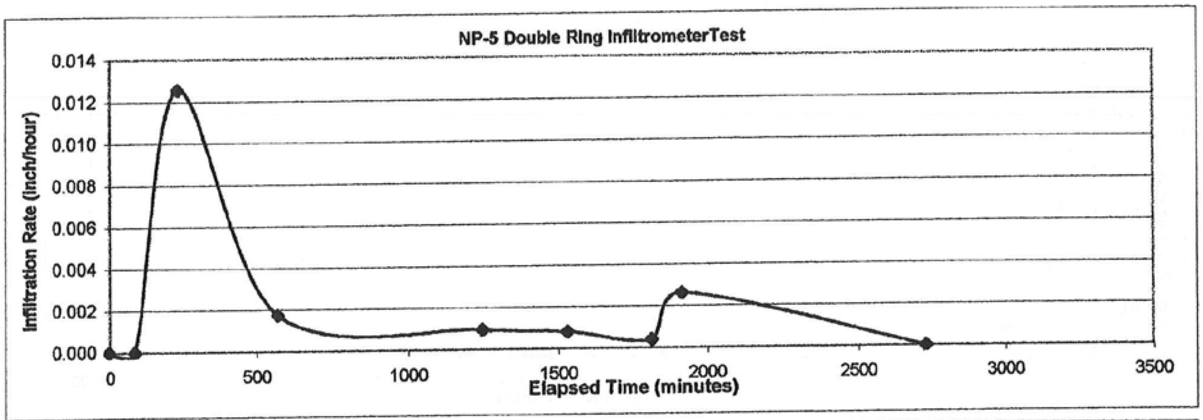


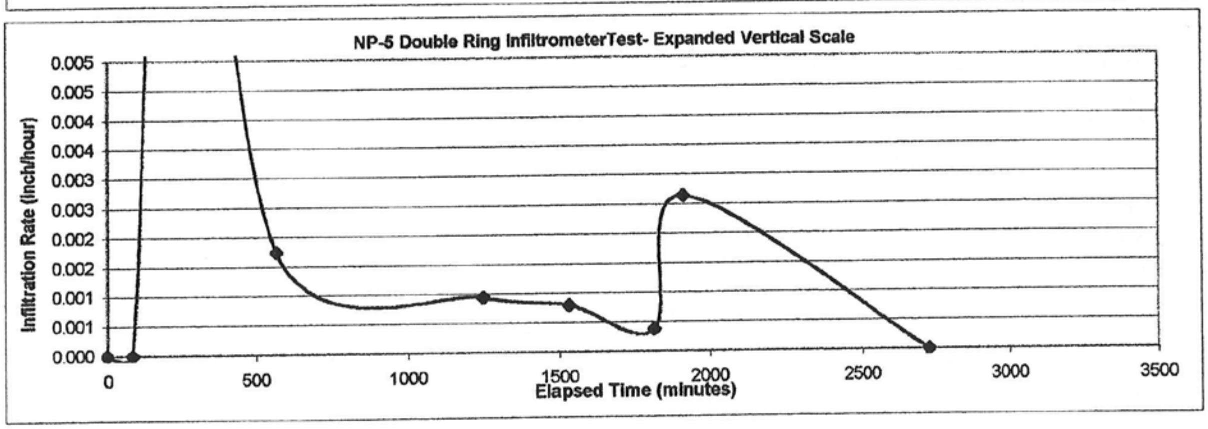


INFILTRATION TEST #4
ON CLAY IN BACKHOE PIT NP-3

DATE	TIME	DEPTH TO WATER IN INNER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/4/02	10:24				SETTING RINGS			
	10:40				FILLED INNER RING			
	10:43	0.495	0	0				
	11:13	0.5	0.005	30	30	0.24000	0.12000	8.47E-05
	14:02	0.52	0.02	199	169	0.14472	0.07236	5.11E-05
	16:18	0.53	0.01	335	136	0.04299	0.02149	1.52E-05
	19:20	0.54	0.01	517	182	0.02785	0.01393	9.83E-06
6/5/02	7:04	0.56	0.02	1221	704	0.02359	0.01179	8.32E-06
	10:21	0.56	0	1418	197	0.00000	0.00000	0.00E+00
	14:12	0.56	0	1649	231	0.00000	0.00000	0.00E+00
	19:35	0.568	0.008	1972	323	0.00584	0.00292	2.06E-06
6/6/02	7:04	0.57	0.002	2661	689	0.00108	0.00054	3.82E-07
	11:47	0.57	0	2944	283	0.00000	0.00000	0.00E+00
	16:32	0.57	0	3229	285	0.00000	0.00000	0.00E+00
	18:12	0.575	0.005	3329	100	0.00216	0.00108	7.63E-07
6/7/02	7:46	0.583	0.008	4143	814	0.00278	0.00139	9.81E-07
	15:29	0.585	0.002	4606	463	0.00063	0.00031	2.21E-07
					Average Infiltration Rate after 1200 minutes		0.00069	4.897E-07

FIGURE C-5. INFILTROMETER TEST RESULTS FOR NP5



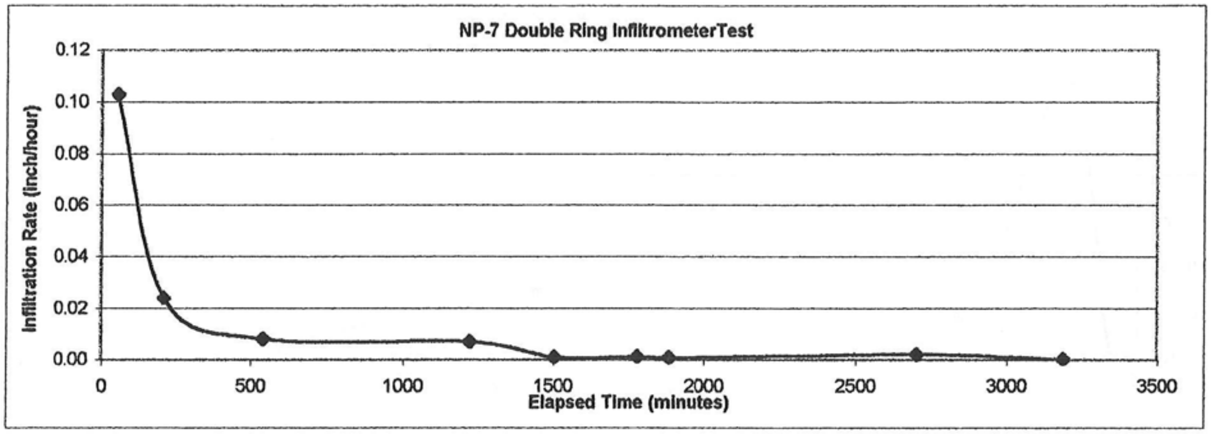


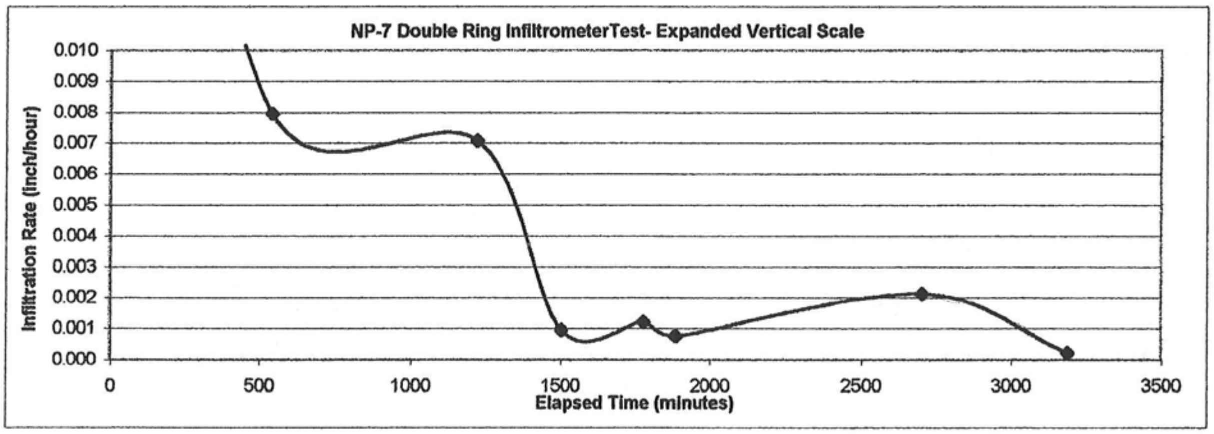
INFILTRATION TEST #5
ON CLAY IN BACKHOE PIT NP-5

DATE	TIME	DEPTH TO WATER IN INNER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/5/02	9:55			SETTING RINGS				
	10:00			FILLED INNER RING				
	10:07	0.135	0	0				
	11:34	0.135	0	87	87	0.00000	0.00000	0.00E+00
	14:03	0.135	0	236	149	0.00000	0.00000	0.00E+00
	19:40	0.145	0.01	573	337	0.02513	0.01257	8.87E-06
6/6/02	6:55	0.148	0.003	1248	675	0.00346	0.00173	1.22E-06
	11:40	0.15	0.002	1533	285	0.00188	0.00094	6.63E-07
	16:24	0.152	0.002	1817	284	0.00159	0.00079	5.59E-07
	18:04	0.153	0.001	1917	100	0.00075	0.00038	2.65E-07
6/7/02	7:36	0.163	0.01	2729	812	0.00528	0.00264	1.86E-06
	15:45	0.163	0	3218	489	0.00000	0.00000	0.00E+00

Average Infiltration Rate after 1000 minutes 0.00108 7.616E-07

FIGURE C-6. INFILTROMETER TEST RESULTS FOR NP7



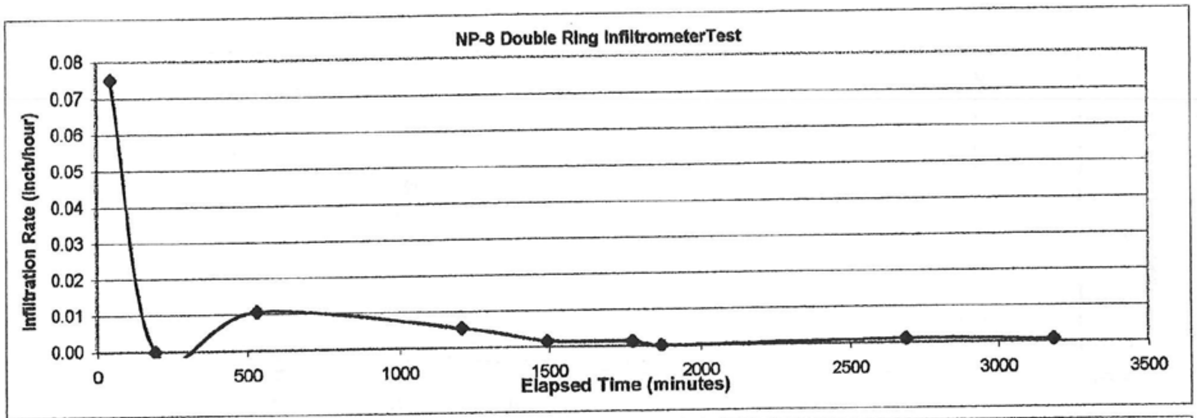


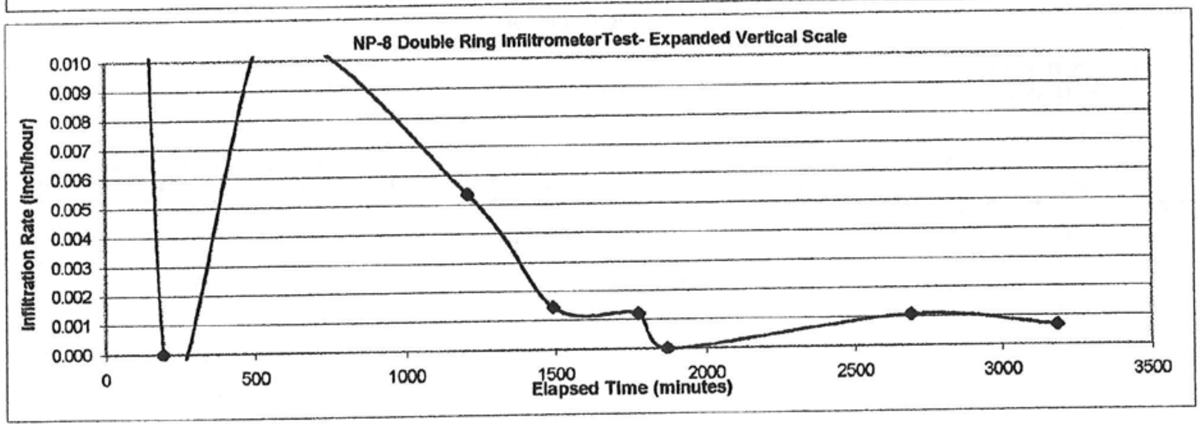
INFILTRATION TEST #6
ON CLAY IN BACKHOE PIT NP-7

DATE	TIME	DEPTH TO WATER IN INNER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/5/02	10:35			SETTING RINGS				
	10:39			FILLED INNER RING				
	10:40	0.155	0	0				
	11:36	0.163	0.008	56	56	**0.20571**	**0.10286**	**7.26E-05**
	14:09	0.17	0.007	209	153	**0.04823**	**0.02411**	**1.70E-05**
	19:44	0.176	0.006	544	335	**0.01588**	**0.00794**	**5.60E-06**
6/6/02	7:02	0.188	0.012	1222	678	**0.01414**	**0.00707**	**4.99E-06**
	11:45	0.19	0.002	1505	283	**0.00191**	**0.00096**	**6.75E-07**
	16:25	0.193	0.003	1785	280	**0.00242**	**0.00121**	**8.54E-07**
	18:10	0.195	0.002	1890	105	**0.00152**	**0.00076**	**5.38E-07**
6/7/02	7:43	0.203	0.008	2703	813	**0.00426**	**0.00213**	**1.50E-06**
	15:50	0.204	0.001	3190	487	**0.00045**	**0.00023**	**1.59E-07**

Average Infiltration Rate after 1500 minutes **0.00106** **7.458E-07**

FIGURE C-7. INFILTROMETER TEST RESULTS FOR NP8



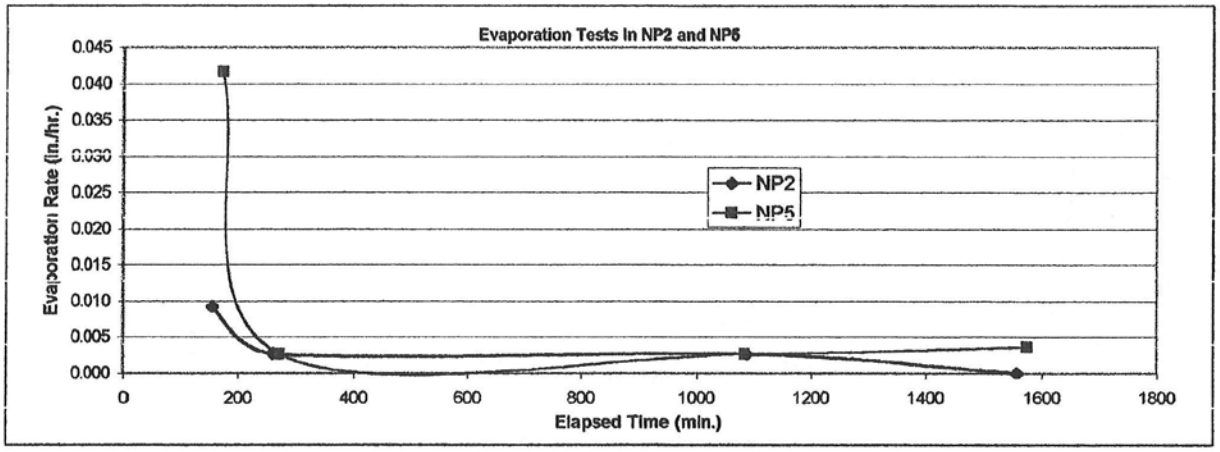


INFILTRATION TEST #7
ON CLAY IN BACKHOE PIT NP-8

DATE	TIME	DEPTH TO WATER IN INNER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	INFILTRATION RATE (FT/DAY)	INFILTRATION RATE (IN/HR)	INFILTRATION RATE (CM/SEC)
6/5/02	10:40			SETTING RINGS				
	10:46			FILLED INNER RING				
	10:50	0.14	0	0				
	11:38	0.145	0.005	48	48	0.15000	0.07500	5.29E-05
	14:07	0.145	0	197	149	0.00000	0.00000	0.00E+00
	19:43	0.153	0.008	533	336	0.02161	0.01081	7.62E-06
6/6/02	7:00	0.162	0.009	1210	677	0.01071	0.00536	3.78E-06
	11:44	0.165	0.003	1494	284	0.00289	0.00145	1.02E-06
	16:27	0.168	0.003	1777	283	0.00243	0.00122	8.58E-07
	18:03	0.168	0	1873	96	0.00000	0.00000	0.00E+00
6/7/02	7:41	0.172	0.004	2691	818	0.00214	0.00107	7.55E-07
	15:55	0.175	0.003	3185	494	0.00136	0.00068	4.78E-07

Average Infiltration Rate after 1400 minutes 0.00088 6.223E-07

FIGURE C-8. EVAPORATION TEST RESULTS FOR NP2 AND NP5



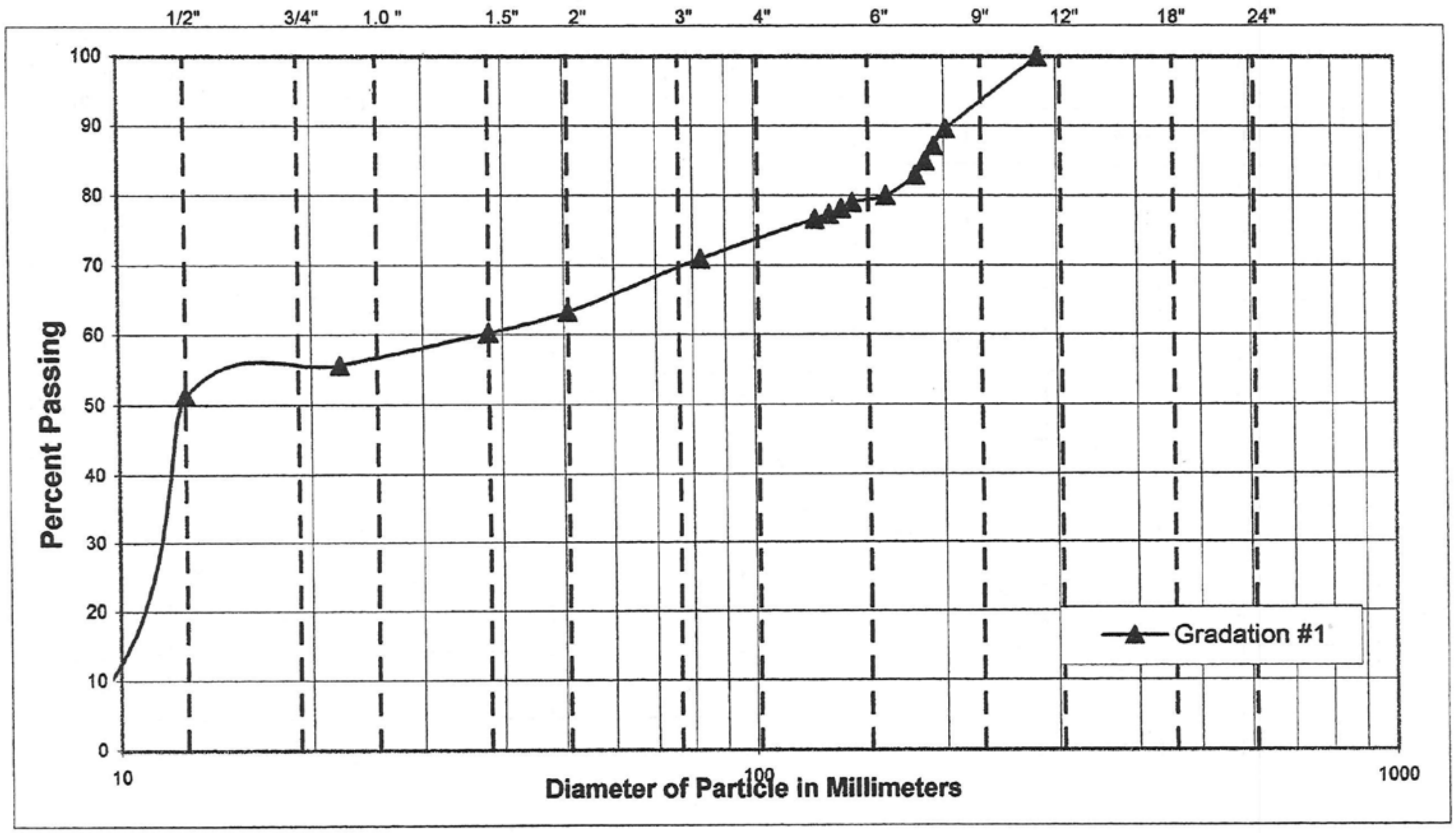
EVAPORATION TEST #1
IN BACKHOE PIT NP-2

DATE	TIME	DEPTH TO WATER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	EVAPORATION RATE (FT/DAY)	EVAPORATION RATE (IN/HR)	EVAPORATION RATE (CM/SEC)
6/6/02	13:38	0.145	0	0				
	16:14	0.147	0.002	156	156	**0.01846**	**0.00923**	**6.51E-06**
	18:00	0.148	0.001	262	106	**0.00550**	**0.00275**	**1.94E-06**
6/7/02	7:48	0.152	0.004	1090	828	**0.00528**	**0.00264**	**1.86E-06**
	15:35	0.152	0	1557	467	**0.00000**	**0.00000**	**0.00E+00**
					Average Evaporation Rate -		**0.00366**	**2.579E-06**

EVAPORATION TEST #2
IN BACKHOE PIT NP-5

DATE	TIME	DEPTH TO WATER RING (FT.)	INCREMENT WATER DEPTH (FT.)	RUN TIME (MIN.)	INCREMENT ELAPSED TIME (MIN.)	EVAPORATION RATE (FT/DAY)	EVAPORATION RATE (IN/HR)	EVAPORATION RATE (CM/SEC)
6/6/02	13:30	0.152	0	0				
	16:23	0.162	0.01	173	173	**0.08324**	**0.04162**	**2.94E-05**
	18:03	0.163	0.001	273	100	**0.00527**	**0.00264**	**1.86E-06**
6/7/02	7:36	0.167	0.004	1086	813	**0.00530**	**0.00265**	**1.87E-06**
	15:44	0.175	0.008	1574	488	**0.00732**	**0.00366**	**2.58E-06**
					Average Evaporation Rate -		**0.01264**	**8.920E-06**

FIGURE C-9. GRADATION TEST RESULTS FOR SOIL COVER SAMPLE RSC1

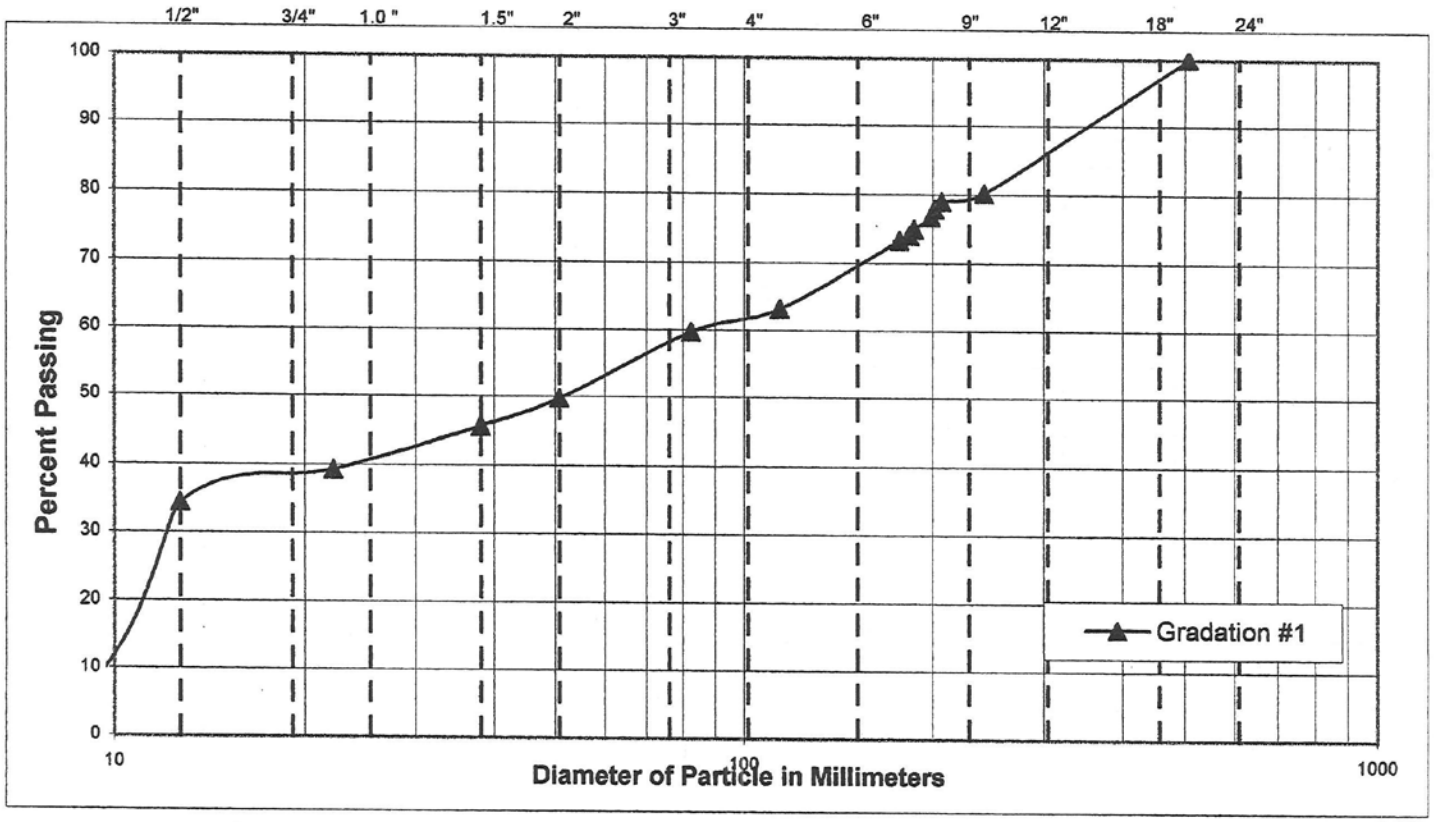


	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)	Shape Factor 1.00	Assumed Sp. Wt.
Gradation Results	0.323	0.37	0.49	4.45	11.08		165

Gradation D50- 0.493

Sample Weight 894

FIGURE C-10. GRADATION TEST RESULTS FOR SOIL COVER SAMPLE RSC2

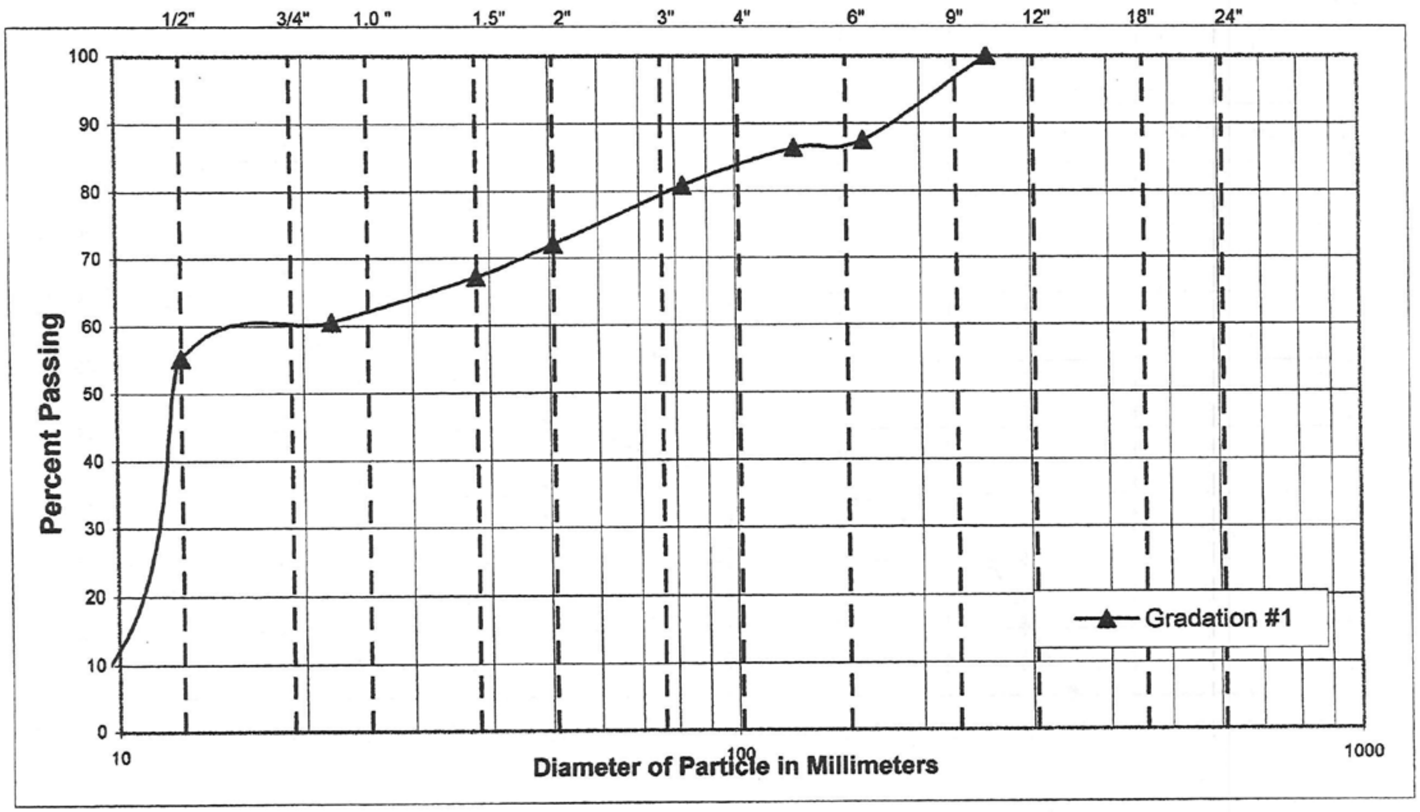


	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)	Shape Factor 1.00	Assumed Sp. Wt.
Gradation Results	0.359	0.43	2.04	7.37	20.00		165

Gradation D50- 2.036

Sample Weight 2235

FIGURE C-11. GRADATION TEST RESULTS FOR QUARRY ROCK SAMPLE QU1



	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)
Gradation Results	0.318	0.36	0.48	2.41	10.13

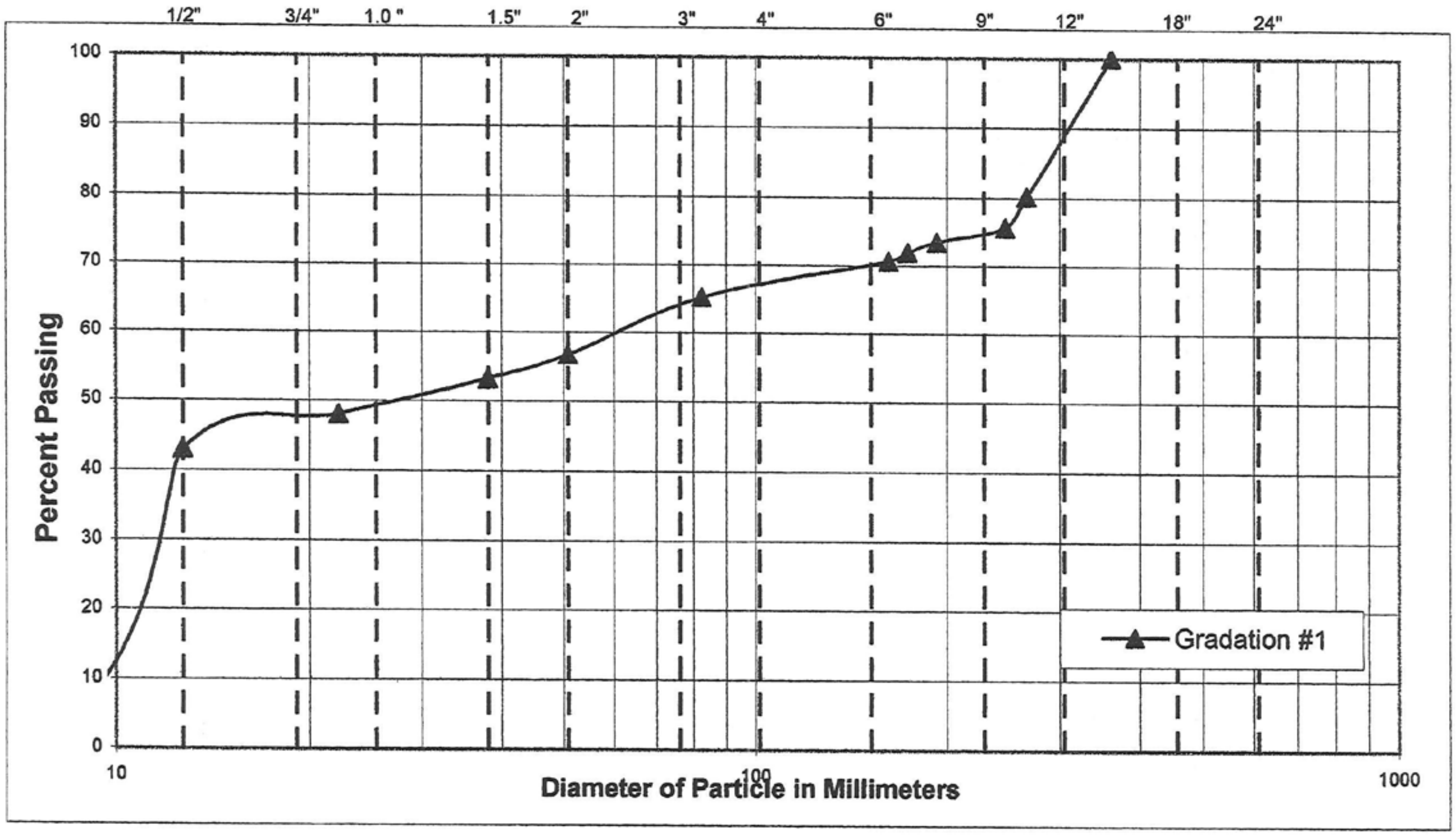
Shape Factor 1.00

Assumed Sp. Wt. 165

Gradation D50- 0.476

Sample Weight 523

FIGURE C-12. GRADATION TEST RESULTS FOR QUARRY ROCK SAMPLE QU2

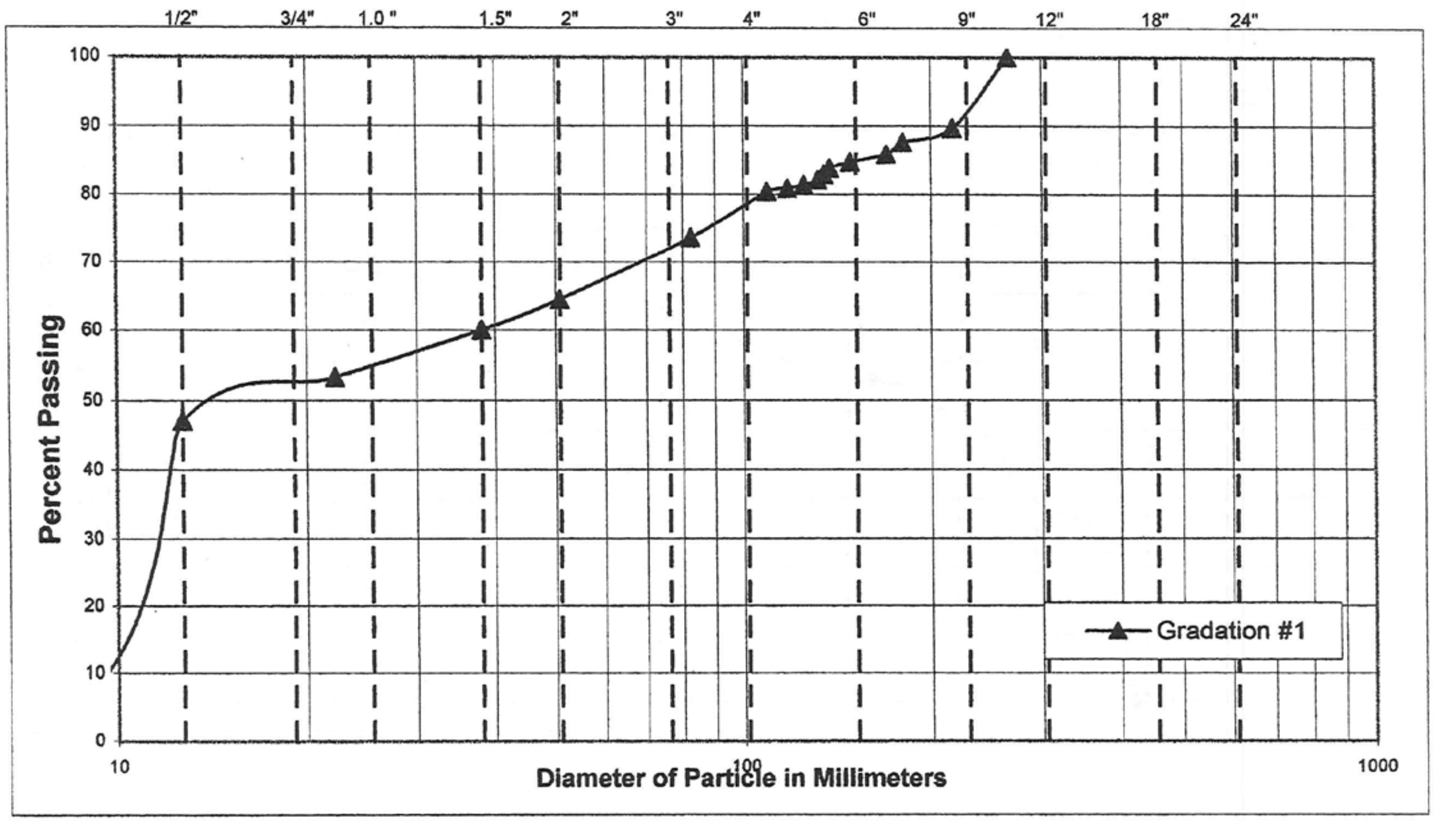


	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)	Shape Factor 1.00	Assumed Sp. Wt.
Gradation Results	0.337	0.40	1.11	9.05	14.23		165

Gradation D50- 1.111

Sample Weight 1020

FIGURE C-13. GRADATION TEST RESULTS FOR QUARRY ROCK SAMPLE QU3



	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)
Gradation Results	0.330	0.38	0.68	3.47	10.45

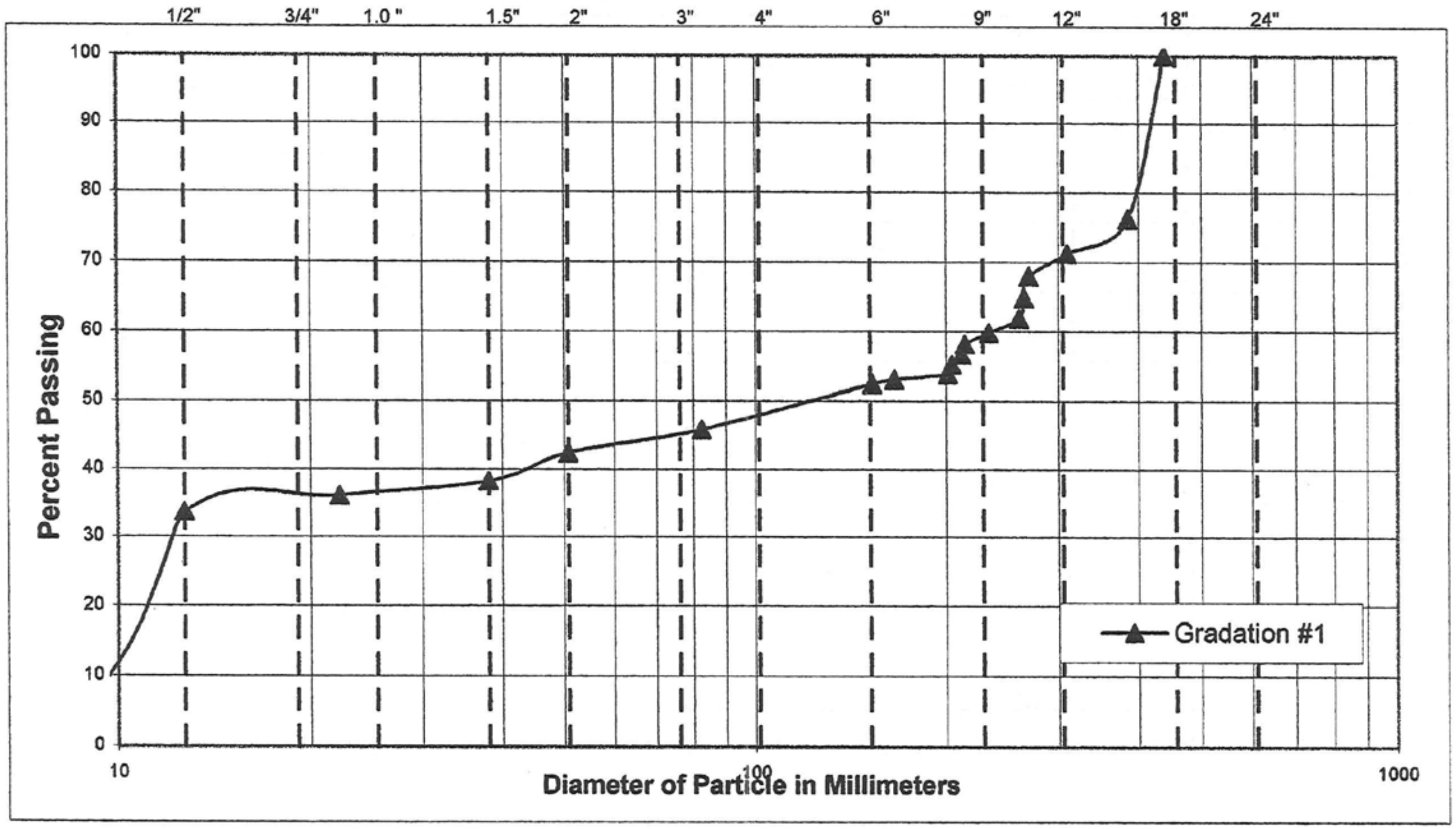
Shape Factor 1.00

Assumed Sp. Wt. 165

Gradation D50- 0.675

Sample Weight 858.5

FIGURE C-14. GRADATION TEST RESULTS FOR TAILINGS DAM ROCK SAMPLE DS1

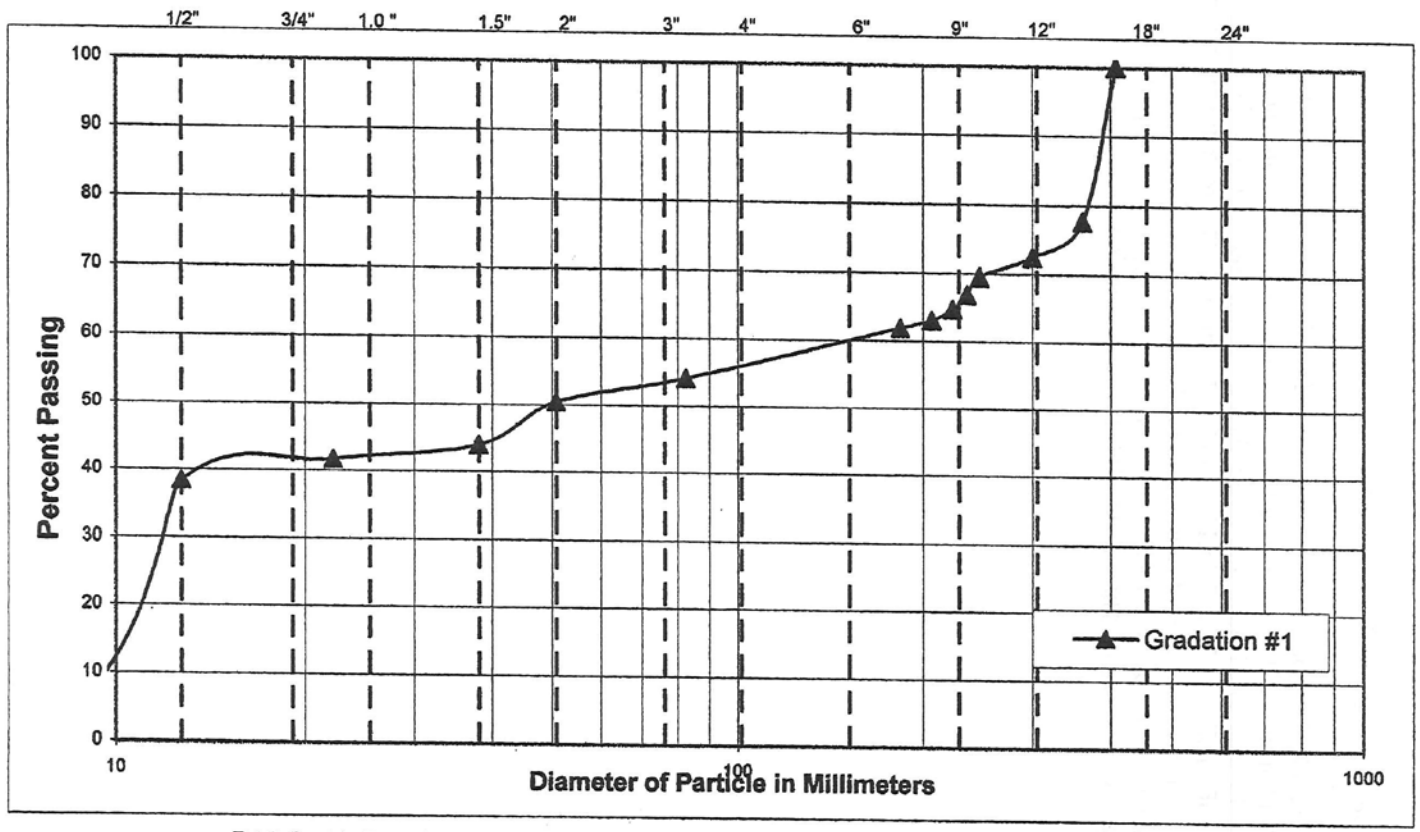


	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)	Shape Factor 1.00	Assumed Sp. Wt.
Gradation Results	0.361	0.44	4.99	14.42	17.33		165

Gradation D50- 4.989

Sample Weight 1833

FIGURE C-15. GRADATION TEST RESULTS FOR TAILINGS DAM ROCK SAMPLE DS2



	D15 (inch)	D25 (inch)	D50 (inch)	D75 (inch)	D100 (inch)
Gradation Results	0.348	0.41	1.97	12.99	16.08

Shape Factor 1.00

Assumed Sp. Wt. 165

Gradation D50- 1.965

Sample Weight 1580

C.6 Shootaring Dam Large Rock Classification

Two 20 foot by 20 foot test areas were selected on the upstream face of the Shootaring Canyon Dam. Within each test area, the visible rocks were classified into three size categories (9 inch to 15 inch, 15 inch to 24 inch, and larger than 24 inch), and also classified by rock type. The number of smaller rocks (<9 inch) was also determined. The rock types included sandstone, andesite porphyry, and a third category currently designated as "other". An approximate weight was assumed for the average rock within each size category, and the proportion of each rock type by weight was estimated. The results of the rock classification are included in Table C-27.

TABLE C-27. Sbootaring Dam Large Rock Classification

AREA1

Ro_ck Classification	< g• Diameter Assume 25 pounds per rock				!> to 15" Diameter Assume 100 pounds per rock			
	#of Rocks	'jb oreacn pe in size bracket rocks	Total Weight of each type In size bracket	% of total sample bV #or bv welaht	#or Rocks	'jt,Oreacn pe in size bracket rocks	Total Weight or each type in size bracket	% ortotal sample bV #or bv welaht
Sandstone	-	-	-	-	69	48.6%	6900	15.3%
Porphyry	-	-	-	-	49	34.5%	4900	10.9%
Other	-	-	-	-	24	16.9%	2400	5.3%
Total	399	-	9975	22.2%	142	-	14200	31.6%

Rock Classification	1o··to 24" ulameter Assume 400 ll<JUnds per rock				> z4" Ulameter Assume 600 pounds per rock			
	#or Rocks	a ite: by# of rocks	Weight or each e in size bracket	% of total sample by weight	#of Rocks	a iJ: bY# of rocks	Total Weight of each type in size bracket	%of total sample by weillht
Sandstone	19	47.5%	7600	16.9%	4	66.7%	3200	7.1%
Porphyry	15	37.5%	6000	13.3%	1	16.7%	800	1.8%
Other	6	15.0%	2400	5.3%	1	16.7%	100	0.2%
Total	40	-	16000	35.6%	6	-	4800	10.7%

AREA2

Rock Classification	< 9Diameter Assume 25 pounds per rock				9" to 15" Diameter Assume 100 pounds per rock			
	#of Rocks	% of each type In size bracket	Total Weight of each type In size bracket	% ortotal sample by weillht	#of Rocks	'jb or eacn_ pe in size bracket by# of rocks	Total Weight of each type In size bracket	% of total sample bv weillht
Sandstone	-	-	-	-	28	27.2%	2800	7.4%
Porphyry	-	-	-	-	32	31.1%	3200	8.5%
Other	-	-	-	-	43	41.7%	4300	9.6%
Total	500	-	12500	33.2%	103	-	10300	27.4%

Rock Classification	15" to 24" Diameter Assume 400 pounds per rock				> 24" Diameter Assume 600 pounds per rock			
	#of Rocks	% of each type bracket	Total Weight or each type in size bracket	% of total sample in size by weight	#or Rocks	'jb or eacn__pe in size bracket by #or rocks	Total Weight of each type in size bracket	% of total sample by weiaht
Sandstone	7	33.3%	2800	7.4%	3	37.5%	2400	6.4%
Porphyry	9	42.9%	3600	9.6%	2	25.0%	1600	43%
Other	5	23.6%	2000	4.4%	3	37.5%	300	0.7%
Total	21	-	8400	22.3%	8	-	6400	17.0%

COMBINATION OF AREAS 1 AND 2

Rock Classification	< S-· Diameter Assume 25 pounds per rock				g· t_1 5" Diameter Assume 100 pounds per rock			
	#of Rocks	% or each type bracket	Total Weight or each type in size bracket	% of total sample in size by weiQht	#of Rocks	'jb or eacn_'Y.pe in size bracket by# of rocks	Total Weight of each type in size bracket	% or total sample by weight
Sandstone	-	-	-	-	97	39.6%	9700	11.7%
Porphyry	-	-	-	-	81	33.1%	8100	9.8%
Other	-	-	-	-	67	27.3%	6700	14.9%
Total	899	-	22475	27.2%	245	-	24500	29.7%

Rock Classification	15" to 24" Diameter Assume 400 pounds per rock				> 24" Diameter Assume 600 POUnds per rock			
	#of Rocks	% of each type size bracket	Weight of each In size bracket	% of total sample in by weight	#of Rocks	%oteacn'Y.pe in size bracket by# of rocks	Total Weight of each type in size bracket	% oftota! mple bywe ht
Sandstone	26	42.6%	10400	12.6%	7	50.0%	5600	6.8%
Porphyry	24	39.3%	9600	11.6%	3	21.4%	2400	2.9%
other	11	18.0%	4400	9.6%	4	26.6%	400	0.9%
Total	61	-	24400	29.5%	14	-	11200	13.6%

NOTE:

Percent Sandstone > g· By Weight= 42.8%
Percent Porphyry > g• By Weight= 33.4%
Pencent other > 9" By Weight = 23.8%

APPENDIX D

SURFACE RUNOFF

APPENDIX D

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APPENDIX D
HEC-1 Runoff Modeling

D.0 Runoff Modeling

The U.S. Army Corps of Engineers (ACOE) HEC-1 flood hydrograph model was used to predict runoff from the Shootaring Canyon area drainage basin. The area was divided into subbasins for the purpose of estimating peak runoff at critical locations under Probable Maximum Flood (PMF) conditions. The HEC-1 model takes input data for precipitation and drainage basin characteristics (Table D-1) and produces output including a flow schematic (Table D-2) and hydrograph data (see Figures D-1 thru D-5).

Table D-1. HEC-1 Input File

```
ID SHOOTARING, TAILINGS AREA DRAINAGE
ID BASED UPON PMF RAINFALL OF 8.25 IN. 1.0 MINUTE INCREMENTS
ID DATE=9/13/02
*FREE
*DIAGRAM
IT 1.0,,,300,,
IO 5,1
IN 1,,
PG HMR49
PC .0000,.0293,.0601,.0924,.1261,.1613,.1980,.2362,.2779,.3197,
PC .3617,.4041,.4476,.4933,.5426,.5970,.6588,.7303,.8143,.9139,
PC1.0325,1.1739,1.3422,1.5420,1.7781,2.0556,2.3800,2.7574,3.1937,3.8905,
PC 4.7050,5.2388,5.6449,5.9950,6.2953,6.5514,6.7687,6.9522,7.1065,7.2360,
PC 7.3446,7.4360,7.5134,7.5797,7.6376,7.6892,7.7364,7.7809,7.8238,7.8659,
PC 7.9078,7.9496,7.9911,8.0285,8.0645,8.0989,8.1319,8.1635,8.1935,8.2221,
PC 8.2500,
KK NORTH
KO 0,,,,21,1,100
BA .082
PR HMR49
LS 0,88
UD .1364
KK NORTHTAILS
KO 0,,,,21,1,100
BA .005
PR HMR49
LS 0,80
UD .0590
KK TAILS
KO 0,,,,21,1,100
BA .022
PR HMR49
LS 0,80
UD .0953
KK TAIL_TO
KO 0,,,,21,1,100
HC 2
KK NRTH_WEST
KO 0,,,,21,1,100
HC 2
KK NRTH_MILL
KO 0,,,,21,1,100
BA .082
PR HMR49
LS 0,88
UD .1364
KK ABV_CNTRL
KO 0,,,,21,1,100
HC 2
KK NRTH_SURGE
KO 0,,,,21,1,300
RS 1,STOR,0,0
SA 0 0.23 0.837 1.286 1.910 2.525 3.109 3.742 4.484 5.739
SQ 0 5 30 40 100 230 498 881 1393 2047
SE 0 2 4 5 6 7 8 9 10 11
KK STH_MILL
KO 0,,,,21,1,100
BA .047
PR HMR49
LS 0,88
```

Table D-1. HEC-1 Input File (continued)

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UD .0919
KK NRTH_TOT
KO 0,,,,21,1,100
HC 2
KK SOUTH
KO 0,,,,21,1,100
BA .127
PR HMR49
LS 0,88
UD .1289
KK TOTAL
KO 0,,,,21,1,100
HC 2
ZZ
```

Table D-2. HEC-1 Flow Schematic

```
                SCHEMATIC DIAGRAM OF STREAM NETWORK

     (V) ROUTING           (--->) DIVERSION OR PUMP FLOW

     (.) CONNECTOR         (<---) RETURN OF DIVERTED OR PUMPED FLOW

      NORTH
          .
          .
          .    NORTHTAILS
          .          .
          .          .
          .          .       TAILS
          .          .           .
          .          .           .
          .     TAIL_TO............
          .          .
          .          .
   NRTH_WES...........
          .
          .
          .    NRTH_MIL
          .          .
          .          .
   ABV_CNTRL..........
          V
          V
   NRTH_SUR
          .
          .
          .    STH_MILL
          .          .
          .          .
   NRTH_TOT...........
          .
          .
          .       SOUTH
          .          .
          .          .
      TOTAL...........

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

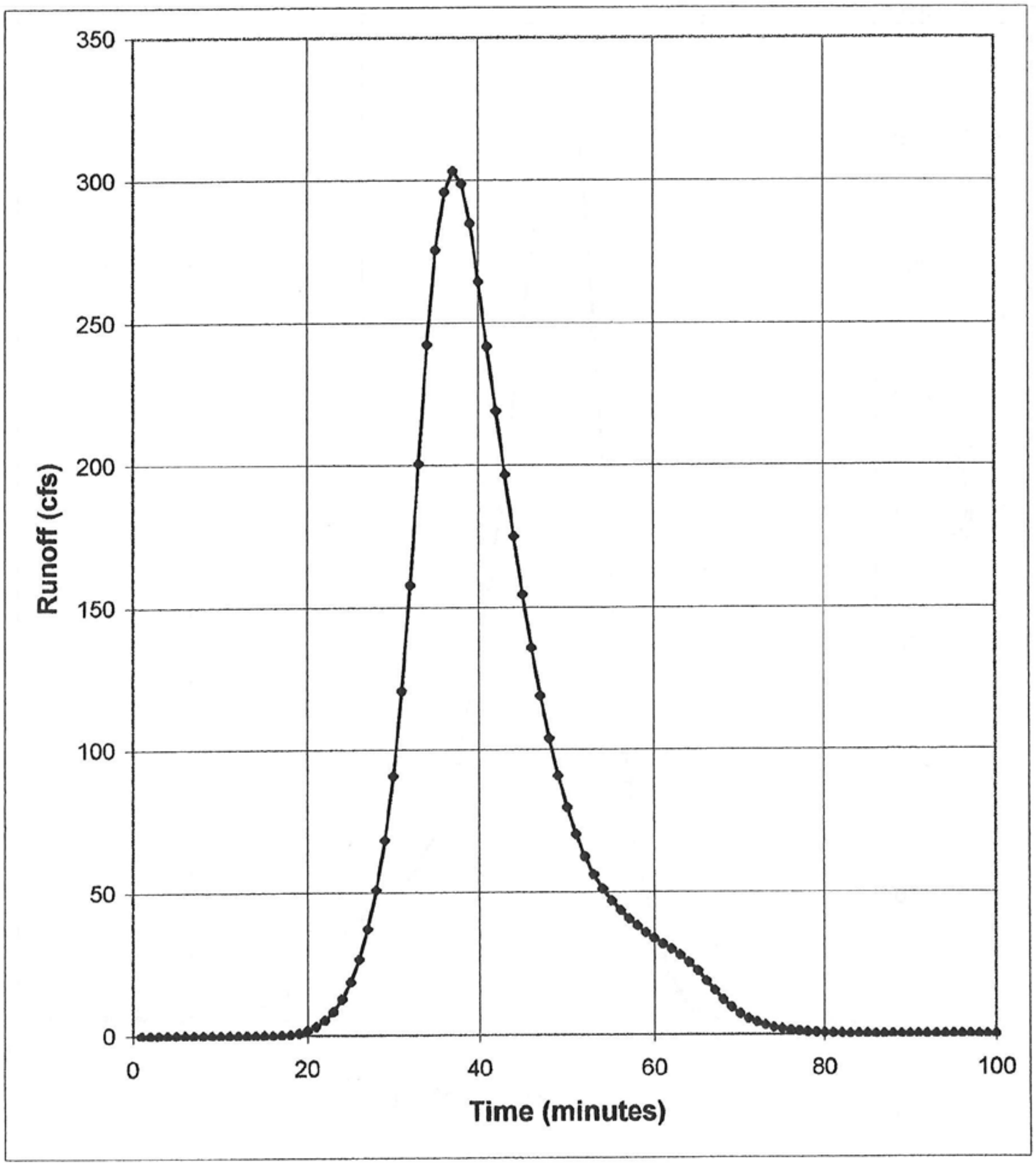

Figure D-1. Hydrograph for Tailings Area Cross-Section HC-1

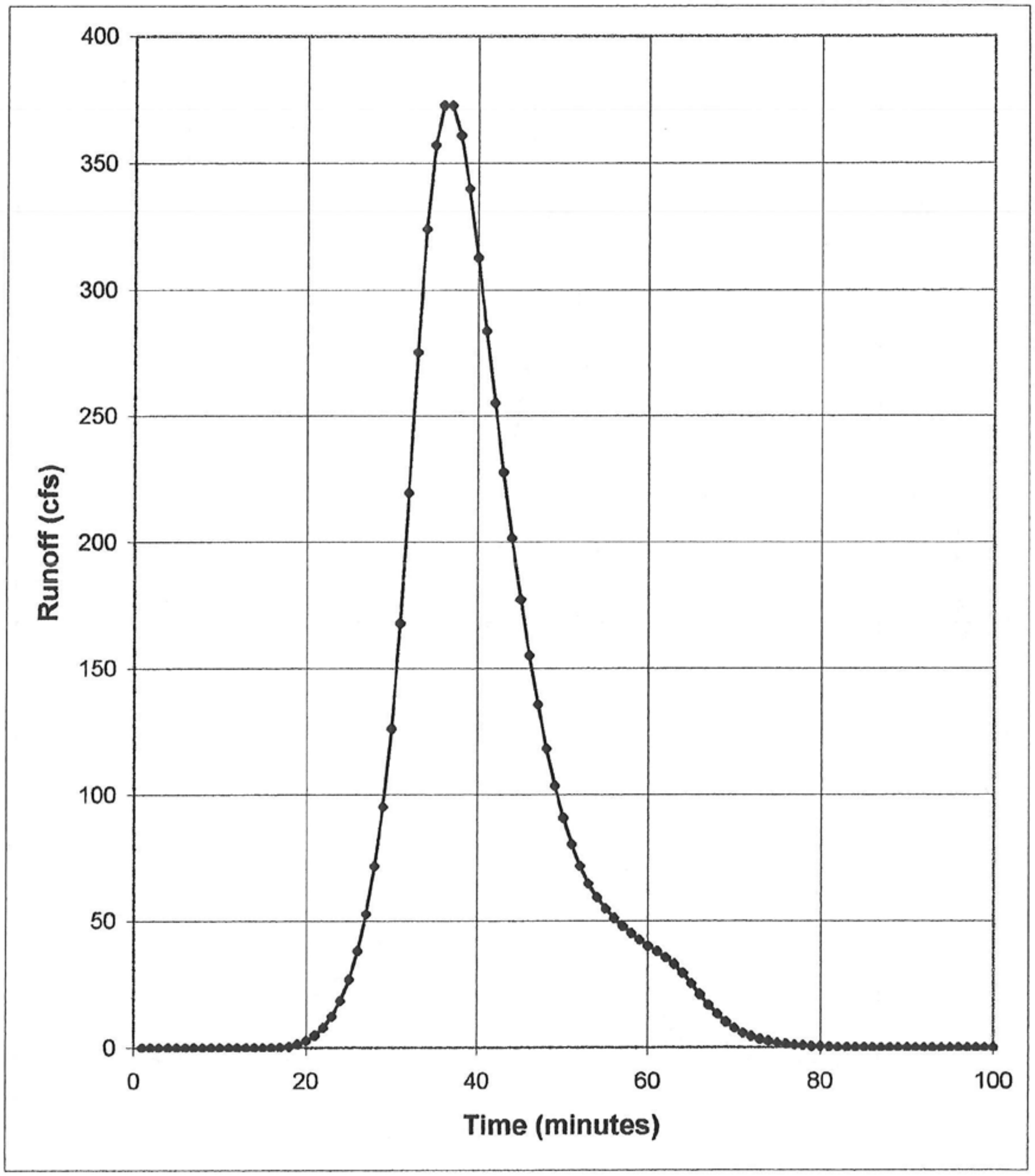

Figure D-2. Hydrograph for Tailings Area Cross-Section HC-2

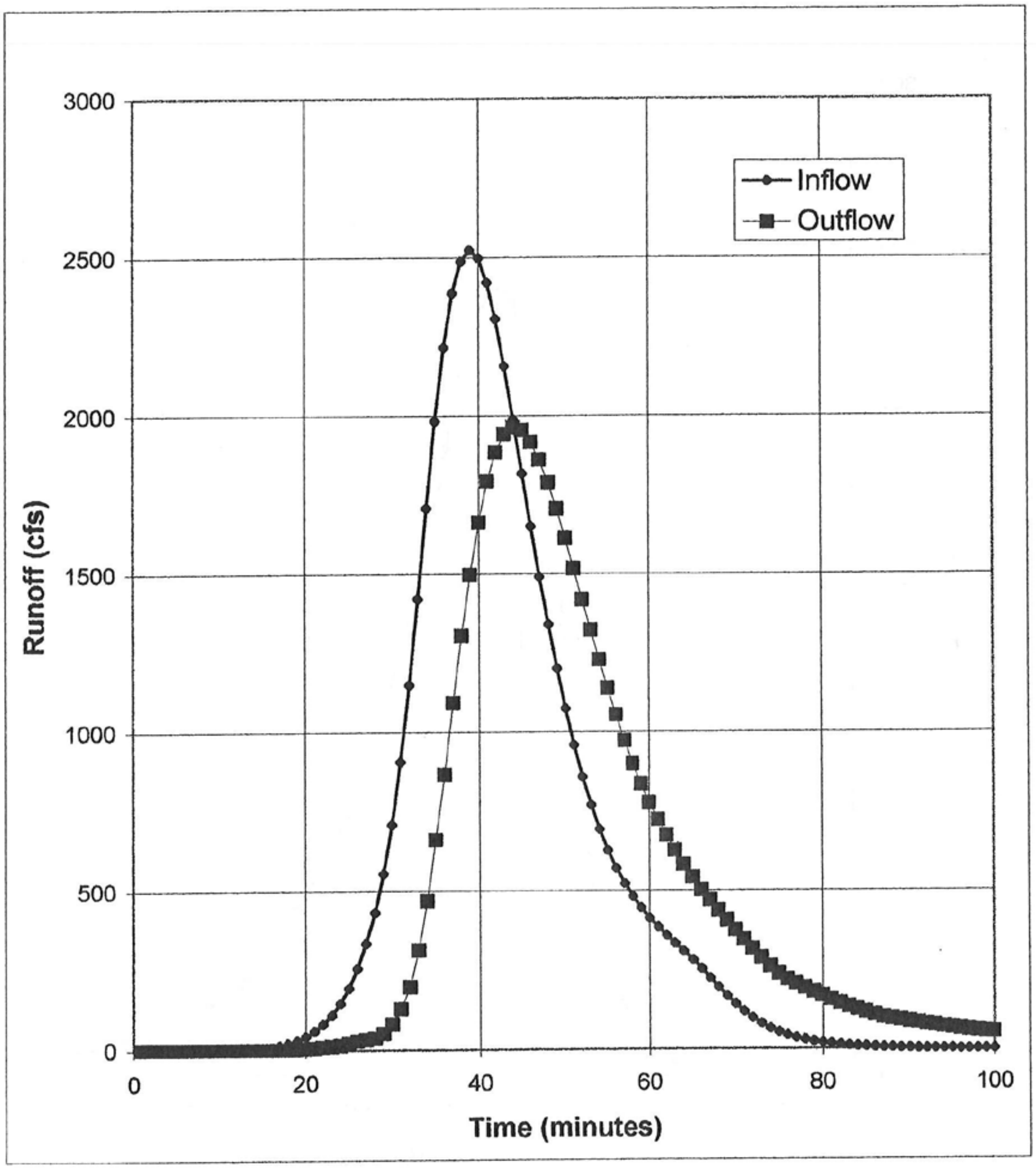

Figure D-3. Hydrographs for the Rock Ledge Inflow and Overflow

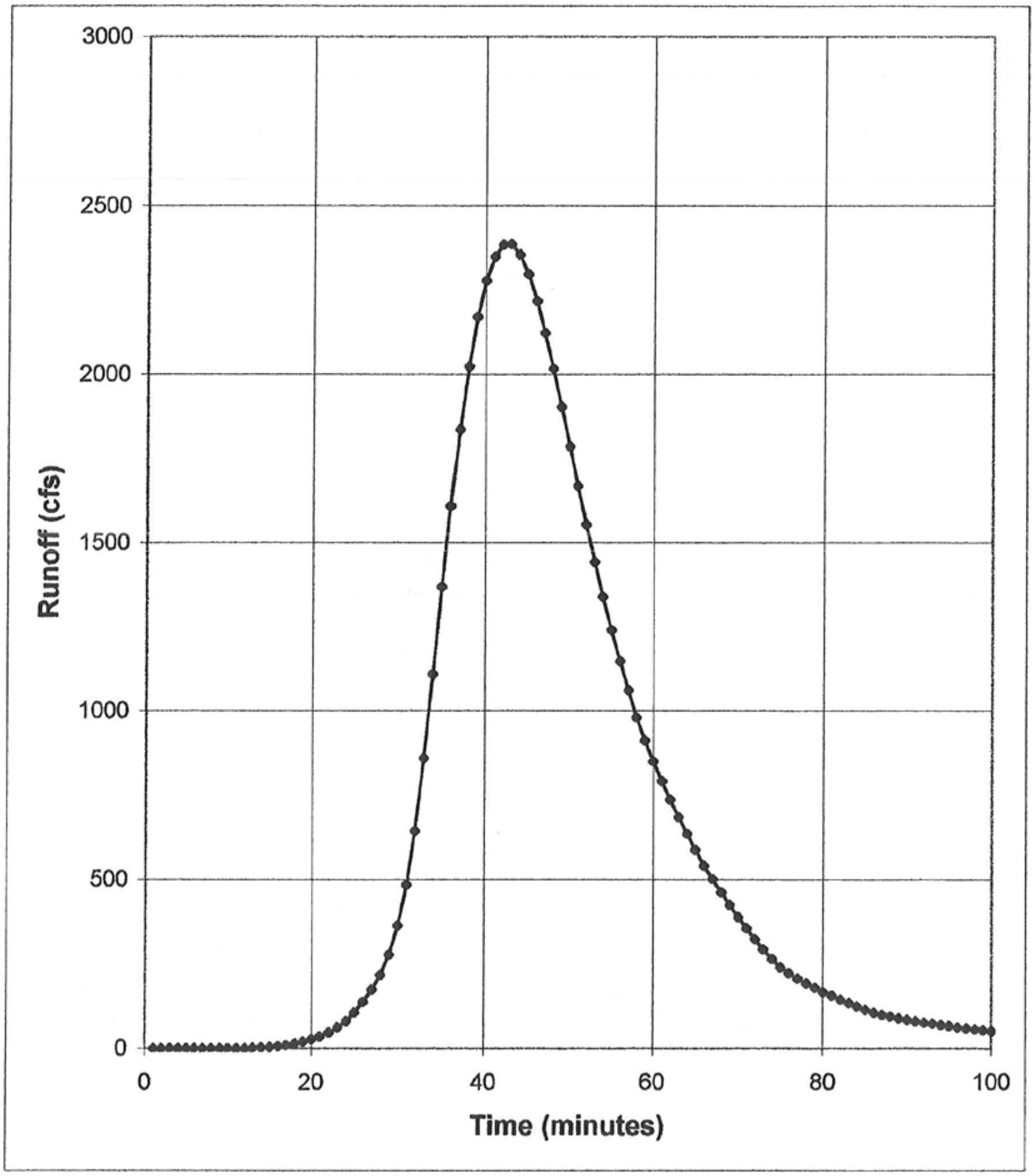

Figure D-4. Hydrograph for Cross-Sections HC-3 and HC-4

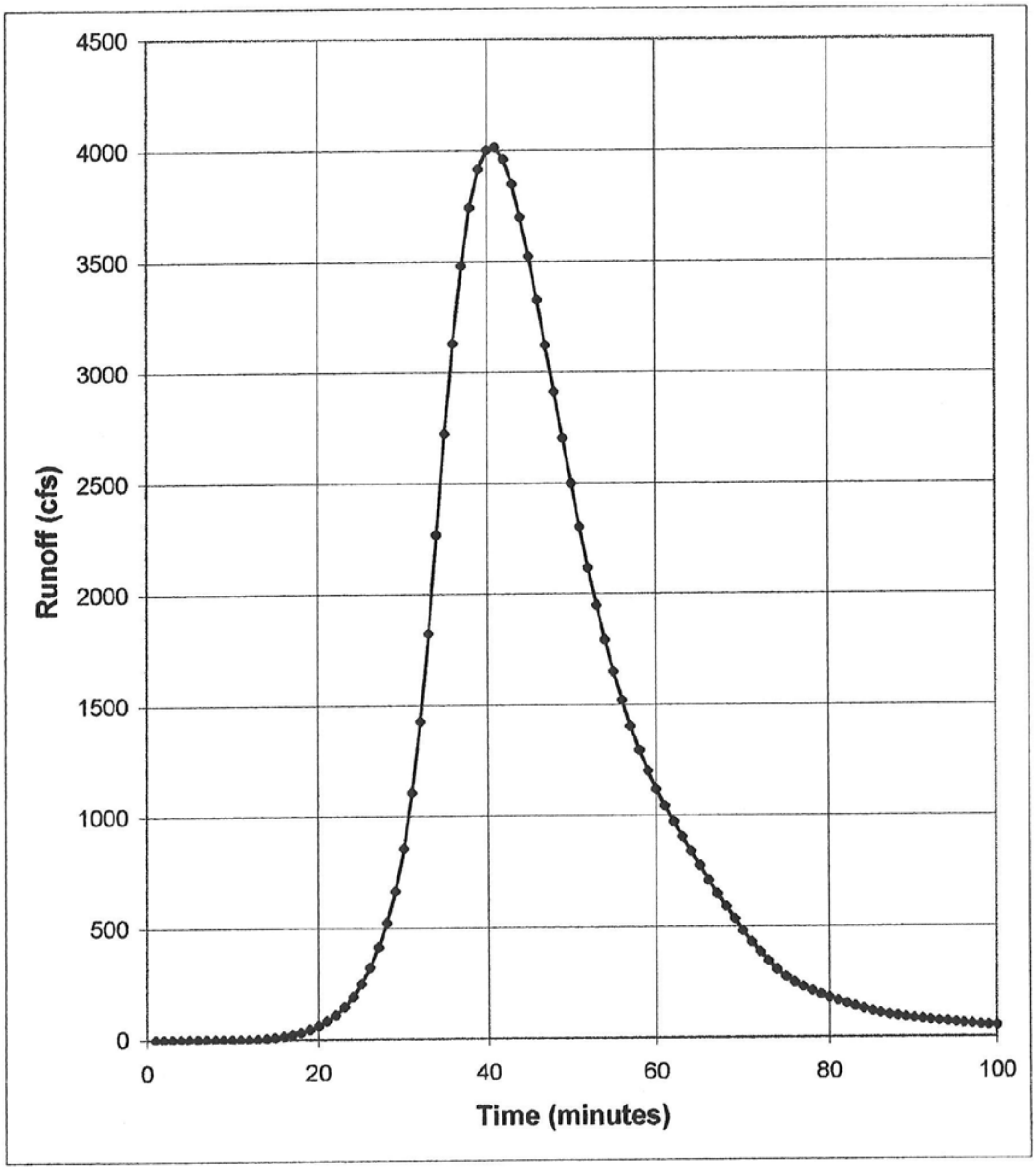

Figure D-5. Hydrograph for Shootaring Canyon Dam Drainage Basin

APPENDIX E

DERIVATION OF SOIL CLEANUP CRITERIA

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Appendix E

Derivation of Soil Cleanup Criteria

E.0 Objective of Analysis

The NRC amended 10 CFR Part 40 on April 12, 1999 (FR/Vol. 64, No. 69, pp 17506-17509) to require uranium recovery licensees to consider radionuclides other than Ra-226 in soil cleanup criteria. The existing soil Ra-226 criterion in 10 CFR Part 40, Appendix A, is used to derive a dose criterion (Benchmark Approach) for the cleanup of byproduct material radionuclides, including Ra-226. The radionuclide-specific criteria are adjusted so that the total dose resulting from the mixture of residual radionuclides will not exceed the Benchmark Dose. The dose from radon is excluded from the benchmark calculation. Other recommended guidance documents include NUREG-1620 and NUREG-1549.

For areas contaminated with uranium tailings, the cleanup limit for Ra-226 is 5 pCi/g above background levels. Section 3 in the main text shows that there are no known areas of windblown uranium tailings at the site nor are there evaporation pond areas where Th-230 may be of concern. Areas contiguous to the tailings pile will be cleaned to the Ra-226 criterion of 5 pCilg above background, where necessary. In the mill area, small process material contaminated areas have been identified, where process materials have a radionuclide mix similar to uranium ore. The only area where significant quantities of contaminants exist is the ore storage area, where ore is presently stored but will be removed and placed in the tailings pile. Therefore, soil cleanup criteria for a radionuclide mix similar to uranium ore has been developed using the Benchmark Approach. It has been assumed that all radionuclides in the U-238 and U-235 decay series are in secular equilibrium.

E.l Exposure Assessment

The exposure assessment is an evaluation of who may be exposed to constituents at the site, how they would be exposed, and how much exposure could occur. The first step for accomplishing this is to identify critical groups who may be potentially exposed. The second step is to develop a conceptual model and associated exposure pathways. The conceptual model includes the source term, mechanism for release, transport medium, and an exposure route. The Benchmark exposure assessment is done for the site where it is assumed that Ra-226 exists in the top 1 5-cm layer of soil at a concentration of 5 pCi/g above background.

E.l.l Potential Receptors

The Bureau of Land Management owns the land contiguous to the site. After mill decommissioning and transfer of the small tailing and rubble disposal cell to the U. S. government, the decontaminated structures will be sold for industrial and/or commercial use. The only parcel of land that a "resident farmer" might purchase is the parcel now called the ore storage area. The ore affected portion of the area is estimated to be approximately 4.5 acres. This receptor scenario is, however, unlikely since most people would choose to live near Ticaboo (3.5 miles away) where electricity is available.

E.1.2 Potential Exposure Pathways

The summers are hot with highs above 100 degrees Fahrenheit. The winters are harsh, with temperatures reaching near zero degrees Fahrenheit. The growing season is quite variable and normally short. The annual precipitation is approximately 17 cm (7 inches).

There is no electrical supply and probably will not be in the near future. There is adequate potable water in the aquifer, approximately 55 meters below surface, for drinking and irrigation water. Vegetation in the area is exclusively native, uncultivated, and generally sparse. The soils are weathered sandstone and would require extensive soil amendments prior to gardening. The extremely hot summers and the poor soil conditions make the growing of grain crops nearly impossible. Vegetable gardening is done in the spring and fall seasons. However, this is normally limited to a few plants suitable for short growing seasons. Fruit-tree blossoms are subject to frequent frost damage and are considered an unreliable crop, possibly bearing fruit only one year out of ten.

All poultry and beef feed would have to be imported at a very high cost, making it very expensive to have chickens and dairy and beef cattle. There are no streams or surface water impoundments that would provide an exposure pathway to waterfowl or other aquatic life. Beef animals may graze on the natural grasses. However, an insignificantly small percentage of the annual diet would come from the sparsely vegetated contaminated area. Therefore radiation exposure to animals and aquatic 1ife or indirect exposure to man via radionuclide uptake in beef or other animals is not considered in this analysis.

In summary, exposure pathways for potential future residents include external radiation, incidental soil ingestion, direct soil ingestion, dust inhalation, and ingestion of contaminated fruit, vegetables, and drinking water. The radon exposure pathway is excluded from the Benchmark Dose modeling approach per guidance from the NRC.

E.1.3 RESRAD Modeling

Exposure was quantified using the RESRAD program, version 6.2 (ANL, 2001). RESRAD is a computer code developed at Argonne National Laboratory for the U. S. Department of Energy and the U.S. Nuclear Regulatory Commission to calculate compliance with soil cleanup dose guidelines. For this application, the soil guideline for site constituents is the dose limit coiTesponding to the dose that a member of the critical group (user of the site) would receive if contamination levels were at the 10 CFR Pmi 40, Appendix A limit for Ra-226 in soil. This Benchmark Dose approach requires that this be calculated for Ra-226 over the time interval of 1000 years. Radon is to be excluded from the calculations. Using the same exposure pathway assumptions, the doses from other constituents at the site are then calculated and compared to the Benchmark Dose. The concentrations of each constituent are adjusted to correspond to the Benchmark Dose. The cleanup criteria for each 1OO-m^2 area of the site will be determined by limiting the sum of the doses from all constituents to the Benchmark Dose. The NRC provides additional guidance for situations where the Benchmark Dose exceeds 100 mrem/y. The NRC also expects that the licensee reduce the concentrations to as low as reasonably achievable (ALARA) levels.

Part 40 of Title 10 of the Code of Federal Regulations, Appendix A, limits the Ra-226 to soil layers deeper than 15 cm to 15 pCi/g. This limit normally applies when backfill is applied. Pathway exposure modeling is difficult for these site specific situations and, therefore, modeling was not done. Consistent with 10 CFR 40, Appendix A it is assumed that the dose is expected to be a factor of three higher from the surface contaminated layer than from buried contaminated soil layers. With this assumption, it will be conservative to scale the Benchmark Dose for Ra-226 and the other constituents by a factor of three and derive cleanup criteria for buried contamination.

As is demonstrated in the main text of this report, the only radionuclides of concern are natural uranium (with daughters). For modeling purposes, we have assumed that the top 15-cm layer is uniformly contaminated and that there is no residual contamination beneath this layer. In our experience at other sites, this is a good assumption for undisturbed surface soils.

RESRAD runs were made for Ra-226 and natural uranium ore. They are attached at the end of this section. Parameters used in the calculations are given along with RESRAD default parameters. The default parameters tend to overestimate the dose but are used when site data are not available. Discussions supporting the use of some of the more important parameters follow. Tables E-1 and E-2 present the parameter values along with the rationale.

Table E-1 RESRAD Site Parameters

Parameter	Units	Value	Rationale
Contaminated Zone Parameters			
Area of Contaminated Zone	m^2	18,000	Approximate size of current contaminated area (305 m x 58 m).
Thickness of Contaminated Zone	m	0.15	Approximate thickness of contaminated soil that will remain after remediation.
Length of Contaminated Zone Parallel to Aquifer Flow	m	305	Length of major side of rectangular area of contamination.
Cover and Contaminated Zone Hydrological Data			
Cover Depth	m	0	No cover is planned as part of this removal action.
Soil Density	g/cm^3	1.84	Site Specific Parameter
Erosion Rate	m/y	0.001	Default value for RESRAD model.
Total Porosity	dimensionless	0.40	Site Specific Parameter
Effective Porosity	dimensionless	0.1	Site Specific Parameter
Field Capacity	dimensionless	0.06	Site Specific Parameter
Hydraulic Conductivity	m/y	22	Site Specific Parameter
b Parameter	dimensionless	1	(NRC, 1999) Table 6.45 value for sand
Evaportranspiration Coefficient	dimensionless	0.5	RESRAD default value
Wind Speed	m/s	2.6	NUREG-0583, 7/77-1/78, site specific
Precipitation	m/y	0.18	Site Specific Parameter
Runoff Coefficient	dimensionless	0.2	RESRAD default value
Watershed Area for Nearby Stream or Pond	m^2	0.1	Stream/pond nearly impossible.
Uncontaminated Unsaturated Zone Parameters			
Unsaturated Zone Thickness	m	55	Site Specific Parameter
Soil Density	g/cm^3	1.84	Site Specific Parameter
Total Soil Porosity	dimensionless	0.4	Site Specific Parameter
Effective Porosity	dimensionless	0.1	Site Specific Parameter
Field Capacity	dimensionless	0.06	Site Specific Parameter
Hydraulic Conductivity	m/y	22	Site Specific Parameter
b Parameter	dimensionless	1	(NRC, 1999) Table 6.45 value for sand
Saturated Zone Parameters			
Soil Density	g/cm^3	1.84	Site Specific Parameter
Total Soil Porosity	dimensionless	0.27	Site Specific Parameter
Effective Porosity	dimensionless	0.1	Site Specific Parameter
Field Capacity	dimensionless	0.06	Site Specific Parameter
Hydraulic Conductivity	m/y	22	Site Specific Parameter
b Parameter	dimensionless	1	(NRC, 1999) Table 6.45 value for sand
Hydraulic Gradient	dimensionless	0.02	RESRAD default value
Water Table Drop Rate	m/y	0.001	RESRAD default value
Well Pump Intake Depth	m	65	Site Specific Parameter
Well Pumping Rate	m^3/year	250	RESRAD default value
Occupancy, Inhalation, and External Gamma Data			
Indoor Dust Filtration Factor	dimensionless	0.4	RESRAD default value
Shielding Factor, External Gamma	dimensionless	0.5	Estimate of the shielding factor for a frame house built on a 3.5-inch thick slab (NRC, 1999)
Shape of Contaminated Zone	rectangle	305 m by 58 m	Approximate shape of contaminated zone-rectangular
Mass Loading for Foliar Deposition	g/m^3	0.001	desert environment (NRC,1999 Table 6.47)
Depth of Soil Mixing Layer	m	0.15	RESRAD default value
Depth of Roots	m	0.9	RESRAD default value
Irrigation Fraction from Groundwater	dimensionless	1	Worst-case assumption.
Storage Times of Contaminated Foodstuffs			
Fruits and Non-Leafy Vegetables	days	14	RESRAD default value
Leafy Vegetables	days	1	RESRAD default value
Well Water	days	1	RESRAD default value
Additional Plant and Fodder Factors			
Wet Weight Crop Yield for Non-Leafy Vegetables	kg/m	0.7	RESRAD default value
Wet Weight Crop Yield for Leafy Vegetables	kg/m	1.5	RESRAD default value
Growing Season for Non-Leafy Vegetables	years	0.17	RESRAD default value
Growing Season for Leafy Vegetables	years	0.25	RESRAD default value
Translocation Factor for Non-Leafy Vegetables	dimensionless	0.1	RESRAD default value
Translocation Factor for Leafy Vegetables	dimensionless	1	RESRAD default value
Dry Foliar Interception Fraction for Non-Leafy Vegetables	dimensionless	0.25	RESRAD default value
Dry Foliar Interception Fraction for Leafy Vegetables	dimensionless	0.25	RESRAD default value
Wet Foliar Interception Fraction for Non-Leafy Vegetables	dimensionless	0.25	RESRAD default value
Wet Foliar Interception Fraction for Leafy Vegetables	dimensionless	0.25	RESRAD default value
Weathering Removal Constant for Vegetation	days	20	RESRAD default value
Radon Data			
Building Foundation Thickness	m	0.15	Typical foundation thickness for buildings (6 inches).
Building Foundation Bulk Density	g/cm^3	2.4	RESRAD default value
Building Foundation Total Porosity	dimensionless	0.1	RESRAD default value
Building Foundation Volumetric Water Content	dimensionless	0.03	RESRAD default value
Building Foundation Radon Diffusion Coefficient	m^2/s	$3x10^{-7}$	RESRAD default value
Contaminated Zone Radon Diffusion Coefficient	m^2/s	$2x10^{-6}$	RESRAD default value
Radon Vertical Dimension of Mixing	m	2	RESRAD default value
Building Air Exchange Rate	1/hour	0.5	RESRAD default value
Building Room Height	m	2.5	RESRAD default value
Building Indoor Area Factor	dimensionless	0	RESRAD default value
Foundation Depth Below Ground Surface	m	-0.15	Assumes slab-on-grade construction with a six-inch thick slab.
Rn-222 Emanation Coefficient	dimensionless	0.25	RESRAD default value
Rn-220 Emanation Coefficient	dimensionless	0.15	RESRAD default value

Table E-2 RESRAD Receptor Parameters

Parameter	Units	On-Site Resident	Rationale
Cover and Contaminated Zone Hydrological Data			
Irrigation Rate	m/y	0.9	(NRC, 1999) Table 6.18
Irrigation Mode	-	overhead	
Occupancy, Inhalation, and External Gamma Data			
Inhalation rate	m^3/y	8,400	RESRAD default value
Mass Loading for Inhalation	g/m^3	0.001	NRC, 1999 Table 6.47
Exposure Duration	y	30	RESRAD default value
Indoor Time Fraction	dimensionless	0.5	RESRAD default value
Outdoor Time Fraction	dimensionless	0.25	RESRAD default value
Ingestion Pathway, Dietary Data			
Fruit, Vegetable, and Grain Consumption	kg/y	160	RESRAD default value
Leafy Vegetable Consumption	kg/y	14	RESRAD default value
Soil Ingestion	g/y	36.5	RESRAD default value
Drinking Water Intake	l/y	510	RESRAD default value
Contaminated Fraction of Drinking Water	dimensionless	1	Worst case
Contaminated Fraction of Irrigation Water	dimensionless	1	Worst case
Contaminated Fraction of Plant Food	dimensionless	0.25	Site Specific Parameter
Mass Loading for Floiar Deposition	g/m^3	0.001	NRC, 1999 Table 6.47

Residency Time

Permanent residents have been chosen as the critical population group. It is assumed that the maximum exposed individual spends 30 years living at the site, spending fifty percent of the time indoors, 25 percent outdoors, and 25 percent elsewhere. It is unlikely that families with children would live in the area since the nearest school is in Hanksville, approximately 60 miles from the site. Therefore, a 30-year exposure time is reasonable.

Food and Water: It is assumed that a well is placed at the down gradient of the site in the center of the contaminated area and that the resident obtains all drinking water from that source. The well is used for irrigation where the resident grows 25 percent of their vegetables and fruit on site. RESRAD default values for food intake were used. We have assumed no intake of contaminated food through milk, meat, or via aquatic pathway.

Area of contaminated zone: The largest contaminated area is the ore storage area which has an affected area of approximately 17,690 m^2 (4.4 acres). This is also the only contaminated area suitable for a resident farmer. The contaminated area is approximated by a 305-m by 58-m rectangular area. The receptor was located at the geometrical center
of this area for the RESRAD calculations.

Length parallel to aquifer flow: The code assumes that the well is placed in the middle of the contaminated zone. We have conservatively assumed the area is rectangular (305 m by 58 m), with the aquifer flow parallel to the 305-m dimension.

Average Annual Wind Speed: Prevailing wind directions and monthly mean wind velocities were measured at the site from August 1977 through July 1978 as reported in NUREG-0583. The average wind speed from these data was calculated to be 2.6 m/s.

Average precipitation: The average annual precipitation rate for the area is 18 em (7. 3 inches), based on one year of site data (NUREG, 0583).

Irrigation: It is conservatively estimated that for a short growing season in this climate, approximately 90 em (35.5 inches) of water will be required (NUREG/CR-5512, Vol. 3).

E.1.4 Results

A RESRAD run was made for the site assuming that the Ra-226 concentration in the contaminated layer was 5 pCi/g. Pb-210, the only long-lived progeny, was also assumed to be present at 3.5 pCi/g. This is consistent with a radon emanating fraction of 0.3. The output shows that the maximum annual dose within the next 1,000 years occurs at t = 0 years and is projected to be 34 mrem. A second run was made with the contaminated layer changed to 100 pCi/g U-nat (48.9 pCi/g for U-238 and U-234 and 2.2 pCi/g for U-235). The progeny concentrations were assumed to be in equilibrium with the exception of those below Rn-222, where the activity of Pb-210 was reduced by 30 percent to allow for the diffusion of radon. No loss of Rn-219 was assumed for the U-235 decay chain because of the very short half life of Rn-219. The computer outputs for both runs are included at the end of this Appendix. The maximum annual dose from the 100 pCi/g U-nat plus progeny run is 374 mrem/y. Using the Benchmark Approach, the cleanup limit for U-nat is (100 pCi/g) x (34/374) = 9. 1 pCi/g or 13.4 mg/kg above natural background concentrations.

E.2 Uncertainty

Calculations (see RESRAD output at the end of this section) show that approximately ninety percent of the total effective dose equivalent (TEDE) results from direct radiation while the majority of the remaining 10 percent comes from the food pathway. Changing to less conservative parameters for the transport of contaminants does not result in the contamination of the aquifer and therefore the water pathway is not of concern. The TEDE primarily depends on the exposure time and the amount of home garden produce consumed. The occupancy time of 50 percent indoors and 25 percent outdoors is the RESRAD default value for the resident farmer and is considered conservative. Similarly, the assumption that 25 percent of the fruit and vegetables come from the contaminated parcel is also very conservative, considering the location. Therefore the results of the calculations are considered very conservative. The maximum calculated TEDE would result from spending an additional 25 percent of the time at the site and eating all fruit and vegetables from the site. This would result in an increase of no more than 60 percent in the calculated TEDE. Therefore the uncertainty in the calculated TEDE is realatively small.

E.3 References

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NUREG-1549. (draft) Decision Methods for Dose Assessment to Comply with Radiological Criteria for License Termination. July 1998. Division of Regulatory Applications, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D. C. 20555.

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NRC, 1999. NUREG/CR-5512, Vol. 3. Residual Radioactive Contamination From Decommissioning. Parameter Analysis. Draft Report for Comment. October 1999. U. S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Washington, DC 20555-0001

ATTACHMENT E-1

RESRAD Benchmark Dose Run

Radium-226 without Radon

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Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Pb-210+D	2.320E-02	2.320E-02	DCF2(1)
B-1	Ra-226+D	8.600E-03	8.600E-03	DCF2(2)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Pb-210+D	7.270E-03	7.270E-03	DCF3(1)
D-1	Ra-226+D	1.330E-03	1.330E-03	DCF3(2)
D-34	Food transfer factors:			
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(1,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(1,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(1,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(2,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(2,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(2,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(1,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(2,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(2,2)

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.800E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.500E-01	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	3.050E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	1.000E+02	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	2.000E+01	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+01	1.000E+00	---	T(2)
R011	Times for calculations (yr)	1.000E+02	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+03	1.000E+01	---	T(4)
R011	Times for calculations (yr)	not used	3.000E+01	---	T(5)
R011	Times for calculations (yr)	not used	1.000E+02	---	T(6)
R011	Times for calculations (yr)	not used	3.000E+02	---	T(7)
R011	Times for calculations (yr)	not used	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used,	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Pb-210	3.500E+00	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Ra-226	5.000E+00	0.000E+00	---	S1(2)
R012	Concentration in groundwater (pCi/L): Pb-210	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(2)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.840E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	6.000E-02	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	2.200E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	1.000E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.600E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.800E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	9.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E-01	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.840E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	2.700E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	6.000E-02	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	2.200E+01	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	1.000E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	5.500E+01	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.840E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	1.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	6.000E-02	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	1.000E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	2.200E+01	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.889E-02	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.698E-02	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-03	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	-1.000E+00	1.000E+00	-1 shows non-circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	1.308E+01	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	2.617E+01	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	3.925E+01	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	5.233E+01	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	6.542E+01	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	7.850E+01	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	9.158E+01	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	1.047E+02	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	1.178E+02	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	1.308E+02	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	1.439E+02	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	1.570E+02	0.000E+00	---	RAD_SHAPE(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	1.000E+00	1.000E+00	---	FRACA(1)
R017	Ring 2	1.000E+00	2.732E-01	---	FRACA(2)
R017	Ring 3	8.000E-01	0.000E+00	---	FRACA(3)
R017	Ring 4	4.300E-01	0.000E+00	---	FRACA(4)
R017	Ring 5	3.300E-01	0.000E+00	---	FRACA(5)
R017	Ring 6	2.600E-01	0.000E+00	---	FRACA(6)
R017	Ring 7	2.200E-01	0.000E+00	---	FRACA(7)
R017	Ring 8	1.900E-01	0.000E+00	---	FRACA(8)
R017	Ring 9	1.700E-01	0.000E+00	---	FRACA(9)
R017	Ring 10	1.500E-01	0.000E+00	---	FRACA(10)
R017	Ring 11	1.300E-01	0.000E+00	---	FRACA(11)
R017	Ring 12	9.300E-02	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	2.500E-01	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-03	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX

Site-Specific Parameter Summary (continued)

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

Summary of Pathway Selections

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

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	18000.00 square meters	Pb-210	3.500E+00
Thickness:	0.15 meters	Ra-226	5.000E+00
Cover Depth:	0.00 meters		

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 1.000E+02 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+01	1.000E+02	1.000E+03
TDOSE(t):	3.386E+01	2.546E+01	1.315E+00	0.000E+00
M(t):	3.386E-01	2.546E-01	1.315E-02	0.000E+00

Maximum TDOSE(t): 3.386E+01 mrem/yr at t = 0.000E+00 years

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	1.209E-02	0.0004	5.126E-02	0.0015	0.000E+00	0.0000	1.808E+00	0.0534	0.000E+00	0.0000	0.000E+00	0.0000	6.772E-01	0.0200
Ra-226	2.914E+01	0.8606	2.859E-02	0.0008	0.000E+00	0.0000	1.949E+00	0.0576	0.000E+00	0.0000	0.000E+00	0.0000	1.940E-01	0.0057
Total	2.915E+01	0.8610	7.985E-02	0.0024	0.000E+00	0.0000	3.757E+00	0.1110	0.000E+00	0.0000	0.000E+00	0.0000	8.712E-01	0.0257

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

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.549E+00	0.0753
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.131E+01	0.9247
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.386E+01	1.0000

*Sum of all water independent and dependent pathways.

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	7.321E-03	0.0003	2.902E-02	0.0011	0.000E+00	0.0000	1.024E+00	0.0402	0.000E+00	0.0000	0.000E+00	0.0000	3.834E-01	0.0151
Ra-226	2.176E+01	0.8547	3.473E-02	0.0014	0.000E+00	0.0000	1.894E+00	0.0744	0.000E+00	0.0000	0.000E+00	0.0000	3.286E-01	0.0129
Total	2.177E+01	0.8550	6.375E-02	0.0025	0.000E+00	0.0000	2.917E+00	0.1146	0.000E+00	0.0000	0.000E+00	0.0000	7.119E-01	0.0280

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

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.443E+00	0.0567
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.402E+01	0.943
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.546E+01	1.0000

*Sum of all water independent and dependent pathways.

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	7.021E-05	0.0001	1.146E-04	0.0001	0.000E+00	0.0000	4.046E-03	0.0031	0.000E+00	0.0000	0.000E+00	0.0000	1.514E-03	0.0012
Ra-226	1.167E+00	0.8877	2.539E-03	0.0019	0.000E+00	0.0000	1.097E-01	0.0834	0.000E+00	0.0000	0.000E+00	0.0000	2.962E-02	0.0225
Total	1.167E+00	0.8878	2.654E-03	0.0020	0.000E+00	0.0000	1.138E-01	0.0865	0.000E+00	0.0000	0.000E+00	0.0000	3.113E-02	0.0237

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

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.745E-03	0.0044
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.309E+00	0.9956
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.315E+00	1.0000

*Sum of all water independent and dependent pathways.

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

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

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.00
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

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

Parent (i)	Product (j)	Branch Fraction*	DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Pb-210	Pb-210	1.000E+00	7.282E-01	4.124E-01	1.641E-03	0.000E+00
Ra-226	Ra-226	1.000E+00	6.249E+00	4.651E+00	2.422E-01	0.000E+00
Ra-226	Pb-210	1.000E+00	1.276E-02	1.530E-01	1.961E-02	0.000E+00
Ra-226	∑DSR(j)		6.262E+00	4.804E+00	2.618E-01	0.000E+00

*Branch Fraction is the cumulative factor for the j't principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
The DSR includes contributions from associated (half-life ≤ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 1.000E+02 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Pb-210	1.373E+02	2.425E+02	6.092E+04	*7.631E+13
Ra-226	1.597E+01	2.082E+01	3.819E+02	*9.882E+11

*At specific activity limit

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

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Pb-210	3.500E+00	0.000E+00	7.282E-01	1.373E+02	7.282E-01	1.373E+02
Ra-226	5.000E+00	0.000E+00	6.262E+00	1.597E+01	6.262E+00	1.597E+01

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

Nuclide (j)	Parent (i)	BRF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Pb-210	Pb-210	1.000E+00	2.549E+00	1.443E+00	5.745E-03	0.000E+00
Pb-210	Ra-226	1.000E+00	6.378E-02	7.651E-01	9.805E-02	0.000E+00
Pb-210	∑DOSE(j)		2.612E+00	2.209E+00	1.038E-01	0.000E+00
Ra-226	Ra-226	1.000E+00	3.125E+01	2.326E+01	1.211E+00	0.000E+00

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Pb-210	Pb-210	1.000E+00	3.500E+00	2.123E+00	2.364E-02	6.912E-22
Pb-210	Ra-226	1.000E+00	0.000E+00	1.058E+00	3.977E-01	8.572E-12
Pb-210	∑S(j):		3.500E+00	3.181E+00	4.213E-01	8.572E-12
Ra-226	Ra-226	1.000E+00	5.000E+00	3.801E+00	3.225E-01	6.223E-12

BRF(i) is the branch fraction of the parent nuclide.

RESCALC.EXE execution time =   5.33 seconds

ATTACHMENT E-2

RESRAD Soil Contamination Run

Natural Uranium

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.720E+00	6.720E+00	DCF2(1)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(2)
B-1	Pb-210+D	2.320E-02	2.320E-02	DCF2(3)
B-1	Ra-226+D	8.600E-03	8.600E-03	DCF2(4)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(5)
B-1	U-234	1.320E-01	1.320E-01	DCF2(6)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(7)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(8)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.480E-02	DCF3(1)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(2)
D-1	Pb-210+D	7.270E-03	7.270E-03	DCF3(3)
D-1	Ra-226+D	1.330E-03	1.330E-03	DCF3(4)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(5)
D-1	U-234	2.830E-04	2.830E-04	DCF3(6)
D-1	U-235+D	2.670E-04	2.670E-04	DCF3(7)
D-1	U-238+D	2.690E-04	2.690E-04	DCF3(8)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(2,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(3,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(3,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(3,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(4,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,3)
D-34				
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(5,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(5,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(5,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(6,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(6,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(6,3)
D-34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(7,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(7,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(7,3)
D-34				

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: FGR 13 Morbidity

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

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.800E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.500E-01	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	3.050E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	1.000E+02	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	2.000E+01	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+01	1.000E+00	---	T(2)
R011	Times for calculations (yr)	1.000E+02	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+03	1.000E+01	---	T(4)
R011	Times for calculations (yr)	not used	3.000E+01	---	T(5)
R011	Times for calculations (yr)	not used	1.000E+02	---	T(6)
R011	Times for calculations (yr)	not used	3.000E+02	---	T(7)
R011	Times for calculations (yr)	not used	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used,	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Ac-227	2.200E+00	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Pa-231	2.200E+00	0.000E+00	---	S1(2)
R012	Initial principal radionuclide (pCi/g): Pb-210	3.420E+01	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Ra-226	4.890E+01	0.000E+00	---	S1(4)
R012	Initial principal radionuclide (pCi/g): Th-230	4.890E+01	0.000E+00	---	S1(5)
R012	Initial principal radionuclide (pCi/g): U-234	4.890E+01	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): U-235	2.200E+00	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g): U-238	4.890E+01	0.000E+00	---	S1(8)
R012	Concentration in groundwater (pCi/L): Ac-227	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Pa-231	not used	0.000E+00	---	W1(2)
R012	Concentration in groundwater (pCi/L): Pb-210	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(4)
R012	Concentration in groundwater (pCi/L): Th-230	not used	0.000E+00	---	W1(5)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(8)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.840E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	6.000E-02	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	2.200E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	1.000E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.600E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.800E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	9.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E-01	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Density of saturated zone (g/cm**3)	1.840E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	2.700E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	6.000E-02	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	2.200E+01	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	1.000E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	5.500E+01	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.840E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	1.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	6.000E-02	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	1.000E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	2.200E+01	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	9.408E-02	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.775E-02	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.889E-02	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.698E-02	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for Th-230				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.152E-05	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.775E-02	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(7,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.775E-02	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(8,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.775E-02	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-03	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	-1.000E+00	1.000E+00	-1 shows non-circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	1.308E+01	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	2.617E+01	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	3.925E+01	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	5.233E+01	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	6.542E+01	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	7.850E+01	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	9.158E+01	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	1.047E+02	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	1.178E+02	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	1.308E+02	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	1.439E+02	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	1.570E+02	0.000E+00	---	RAD_SHAPE(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	1.000E+00	1.000E+00	---	FRACA(1)
R017	Ring 2	1.000E+00	2.732E-01	---	FRACA(2)
R017	Ring 3	8.000E-01	0.000E+00	---	FRACA(3)
R017	Ring 4	4.300E-01	0.000E+00	---	FRACA(4)
R017	Ring 5	3.300E-01	0.000E+00	---	FRACA(5)
R017	Ring 6	2.600E-01	0.000E+00	---	FRACA(6)
R017	Ring 7	2.200E-01	0.000E+00	---	FRACA(7)
R017	Ring 8	1.900E-01	0.000E+00	---	FRACA(8)
R017	Ring 9	1.700E-01	0.000E+00	---	FRACA(9)
R017	Ring 10	1.500E-01	0.000E+00	---	FRACA(10)
R017	Ring 11	1.300E-01	0.000E+00	---	FRACA(11)
R017	Ring 12	9.300E-02	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	2.500E-01	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-03	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used,	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX

Site-Specific Parameter Summary (continued)

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

Summary of Pathway Selections

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

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	18000.00 square meters	Ac-227	2.200E+00
Thickness:	0.15 meters	Pa-231	2.200E+00
Cover Depth:	0.00 meters	Pb-210	3.420E+01
		Ra-226	4.890E+01
		Th-230	4.890E+01
		U-234	4.890E+01
		U-235	2.200E+00
		U-238	4.890E+01

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 1.000E+02 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+01	1.000E+02	1.000E+03
TDOSE(t):	3.738E+02	2.780E+02	1.968E+01	3.601E-12
M(t):	3.738E+00	2.780E+00	1.968E-01	3.601E-14

Maximum TDOSE(t): 3.738E+02 mrem/yr at t = 0.000E+00 years

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	2.333E+00	0.0062	8.991E+00	0.0241	0.000E+00	0.0000	5.706E-01	0.0015	0.000E+00	0.0000	0.000E+00	0.0000	8.348E-01	0.0022
Pa-231	2.689E-01	0.0007	1.933E+00	0.0052	0.000E+00	0.0000	1.679E+00	0.0045	0.000E+00	0.0000	0.000E+00	0.0000	6.378E-01	0.0017
Pb-210	1.181E-01	0.0003	5.009E-01	0.0013	0.000E+00	0.0000	1.767E+01	0.0473	0.000E+00	0.0000	0.000E+00	0.0000	6.617E+00	0.0177
Ra-226	2.850E+02	0.7624	2.796E-01	0.0007	0.000E+00	0.0000	1.906E+01	0.0510	0.000E+00	0.0000	0.000E+00	0.0000	1.897E+00	0.0051
Th-230	9.620E-02	0.0003	1.032E+01	0.0276	0.000E+00	0.0000	2.118E-01	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	7.315E-01	0.0020
U-234	1.112E-02	0.0000	4.100E+00	0.0110	0.000E+00	0.0000	2.529E-01	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	3.705E-01	0.0010
U-235	9.331E-01	0.0025	1.719E-01	0.0005	0.000E+00	0.0000	1.075E-02	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.573E-02	0.0000
U-238	3.957E+00	0.0106	3.665E+00	0.0098	0.000E+00	0.0000	2.404E-01	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	3.522E-01	0.0009
Total	2.927E+02	0.7830	2.996E+01	0.0801	0.000E+00	0.0000	3.969E+01	0.1062	0.000E+00	0.0000	0.000E+00	0.0000	1.146E+01	0.0306

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

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.273E+01	0.0341
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.518E+00	0.0121
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.490E+01	0.0666
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.062E+02	0.8192
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.136E+01	0.0304
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.734E+00	0.0127
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.132E+00	0.0030
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.214E+00	0.0220
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.738E+02	1.0000

*Sum of all water independent and dependent pathways.

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	6.565E-01	0.0024	2.382E+00	0.0086	0.000E+00	0.0000	1.512E-01	0.0005	0.000E+00	0.0000	0.000E+00	0.0000	2.211E-01	0.0008
Pa-231	5.180E-01	0.0019	2.453E+00	0.0088	0.000E+00	0.0000	1.152E+00	0.0041	0.000E+00	0.0000	0.000E+00	0.0000	5.209E-01	0.0019
Pb-210	7.154E-02	0.0003	2.835E-01	0.0010	0.000E+00	0.0000	1.000E+01	0.0360	0.000E+00	0.0000	0.000E+00	0.0000	3.746E+00	0.0135
Ra-226	2.129E+02	0.7656	3.397E-01	0.0012	0.000E+00	0.0000	1.852E+01	0.0666	0.000E+00	0.0000	0.000E+00	0.0000	3.213E+00	0.0116
Th-230	1.156E+00	0.0042	9.624E+00	0.0346	0.000E+00	0.0000	2.772E-01	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	6.936E-01	0.0025
U-234	7.676E-03	0.0000	2.623E+00	0.0094	0.000E+00	0.0000	1.618E-01	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	2.371E-01	0.0009
U-235	6.362E-01	0.0023	1.104E-01	0.0004	0.000E+00	0.0000	7.116E-03	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.017E-02	0.0000
U-238	2.676E+00	0.0096	2.345E+00	0.0084	0.000E+00	0.0000	1.538E-01	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	2.253E-01	0.0008
Total	2.186E+02	0.7862	2.016E+01	0.0725	0.000E+00	0.0000	3.042E+01	0.1094	0.000E+00	0.0000	0.000E+00	0.0000	8.868E+00	0.0319

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

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.410E+00	0.0123
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.643E+00	0.0167
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.410E+01	0.0507
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.349E+02	0.8450
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.175E+01	0.0423
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.030E+00	0.0109
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.638E-01	0.0027
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.399E+00	0.0194
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.780E+02	1.0000

*Sum of all water independent and dependent pathways.

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	5.631E-06	0.0000	1.012E-05	0.0000	0.000E+00	0.0000	6.432E-07	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.400E-07	0.0000
Pa-231	1.803E-02	0.0009	3.926E-02	0.0020	0.000E+00	0.0000	1.430E-02	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	7.119E-03	0.0004
Pb-210	6.861E-04	0.0000	1.120E-03	0.0001	0.000E+00	0.0000	3.953E-02	0.0020	0.000E+00	0.0000	0.000E+00	0.0000	1.480E-02	0.0008
Ra-226	1.142E+01	0.5801	2.483E-02	0.0013	0.000E+00	0.0000	1.073E+00	0.0545	0.000E+00	0.0000	0.000E+00	0.0000	2.897E-01	0.0147
Th-230	2.676E+00	0.1360	3.405E+00	0.1730	0.000E+00	0.0000	2.340E-01	0.0119	0.000E+00	0.0000	0.000E+00	0.0000	2.771E-01	0.0141
U-234	7.938E-04	0.0000	3.193E-02	0.0016	0.000E+00	0.0000	1.971E-03	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	2.877E-03	0.0001
U-235	1.619E-02	0.0008	1.383E-03	0.0001	0.000E+00	0.0000	1.116E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.341E-04	0.0000
U-238	6.120E-02	0.0031	2.785E-02	0.0014	0.000E+00	0.0000	1.828E-03	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	2.676E-03	0.0001
Total	1.419E+01	0.7210	3.532E+00	0.1795	0.000E+00	0.0000	1.365E+00	0.0694	0.000E+00	0.0000	0.000E+00	0.0000	5.944E-01	0.0302

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

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.734E-05	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.871E-02	0.0040
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.614E-02	0.0029
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.280E+01	0.6506
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.592E+00	0.3350
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.757E-02	0.0019
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.781E-02	0.0009
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.355E-02	0.0048
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.968E+01	1.0000

*Sum of all water independent and dependent pathways.

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

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

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	2.600E-12	0.7220	0.000E+00	0.0000	0.000E+00	0.0000	4.498E-13	0.1249	0.000E+00	0.0000	0.000E+00	0.0000	3.050E-12	0.8469
Pa-231	4.700E-13	0.1305	0.000E+00	0.0000	0.000E+00	0.0000	8.112E-14	0.0225	0.000E+00	0.0000	0.000E+00	0.0000	5.512E-13	0.1531
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	1.485E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.559E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.741E-16	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	3.070E-12	0.8526	0.000E+00	0.0000	0.000E+00	0.0000	5.309E-13	0.1474	0.000E+00	0.0000	0.000E+00	0.0000	3.601E-12	1.0000

*Sum of all water independent and dependent pathways.

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

Parent (i)	Product (j)	Branch Fraction*	DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Ac-227	Ac-227	1.000E+00	5.786E+00	1.550E+00	7.881E-06	1.386E-12
Pa-231	Pa-231	1.000E+00	1.960E+00	1.258E+00	1.576E-02	0.000E+00
Pa-231	Ac-227	1.000E+00	9.352E-02	8.525E-01	2.001E-02	2.505E-13
Pa-231	∑DSR(j)		2.054E+00	2.110E+00	3.578E-02	2.505E-13
Pb-210	Pb-210	1.000E+00	7.282E-01	4.124E-01	1.641E-03	0.000E+00
Ra-226	Ra-226	1.000E+00	6.249E+00	4.651E+00	2.422E-01	0.000E+00
Ra-226	Pb-210	1.000E+00	1.276E-02	1.530E-01	1.961E-02	0.000E+00
Ra-226	∑DSR(j)		6.262E+00	4.804E+00	2.618E-01	0.000E+00
Th-230	Th-230	1.000E+00	2.309E-01	2.154E-01	7.650E-02	0.000E+00
Th-230	Ra-226	1.000E+00	1.354E-03	2.450E-02	5.618E-02	0.000E+00
Th-230	Pb-210	1.000E+00	1.978E-06	4.033E-04	2.127E-03	0.000E+00
Th-230	∑DSR(j)		2.322E-01	2.403E-01	1.348E-01	0.000E+00
U-234	U-234	1.000E+00	9.681E-02	6.194E-02	7.382E-04	0.000E+00
U-234	Th-230	1.000E+00	1.027E-06	1.681E-05	1.785E-05	0.000E+00
U-234	Ra-226	1.000E+00	4.025E-09	1.065E-06	1.185E-05	0.000E+00
U-234	Pb-210	1.000E+00	4.650E-12	1.239E-08	4.126E-07	0.000E+00
U-234	∑DSR(j)		9.681E-02	6.196E-02	7.683E-04	0.000E+00
U-235	U-235	1.000E+00	5.143E-01	3.468E-01	8.026E-03	0.000E+00
U-235	Pa-231	1.000E+00	2.023E-05	2.791E-04	3.355E-05	0.000E+00
U-235	Ac-227	1.000E+00	6.651E-07	1.092E-04	3.780E-05	7.914E-17
U-235	∑DSR(j)		5.143E-01	3.472E-01	8.098E-03	7.914E-17
U-238	U-238	1.000E+00	1.680E-01	1.104E-01	1.913E-03	0.000E+00
U-238	U-234	1.000E+00	1.362E-07	1.843E-06	2.103E-07	0.000E+00
U-238	Th-230	1.000E+00	9.646E-13	2.339E-10	1.224E-09	0.000E+00
U-238	Ra-226	1.000E+00	2.835E-15	1.013E-11	7.055E-10	0.000E+00
U-238	Pb-210	1.000E+00	2.738E-18	9.112E-14	2.221E-11	0.000E+00
U-238	∑DSR(j)		1.680E-01	1.104E-01	1.913E-03	0.000E+00

*Branch Fraction is the cumulative factor for the j't principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
The DSR includes contributions from associated (half-life ≤ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 1.000E+02 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Ac-227	1.728E+01	6.451E+01	1.269E+07	7.214E+13
Pa-231	4.869E+01	4.738E+01	2.795E+03	*4.722E+10
Pb-210	1.373E+02	2.425E+02	6.092E+04	*7.631E+13
Ra-226	1.597E+01	2.082E+01	3.819E+02	*9.882E+11
Th-230	4.306E+02	4.162E+02	7.418E+02	*2.018E+10
U-234	1.033E+03	1.614E+03	1.302E+05	*6.245E+09
U-235	1.944E+02	2.880E+02	1.235E+04	*2.160E+06
U-238	5.953E+02	9.057E+02	5.227E+04	*3.360E+05

*At specific activity limit

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

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Ac-227	2.200E+00	0.000E+00	5.786E+00	1.728E+01	5.786E+00	1.728E+01
Pa-231	2.200E+00	4.711 ± 0.009	2.247E+00	4.451E+01	2.054E+00	4.869E+01
Pb-210	3.420E+01	0.000E+00	7.282E-01	1.373E+02	7.282E-01	1.373E+02
Ra-226	4.890E+01	0.000E+00	6.262E+00	1.597E+01	6.262E+00	1.597E+01
Th-230	4.890E+01	18.27 ± 0.04	2.422E-01	4.129E+02	2.322E-01	4.306E+02
U-234	4.890E+01	0.000E+00	9.681E-02	1.033E+03	9.681E-02	1.033E+03
U-235	2.200E+00	0.000E+00	5.143E-01	1.944E+02	5.143E-01	1.944E+02
U-238	4.890E+01	0.000E+00	1.680E-01	5.953E+02	1.680E-01	5.953E+02

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

Nuclide (j)	Parent (i)	BRF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Ac-227	Ac-227	1.000E+00	1.273E+01	3.410E+00	1.734E-05	3.050E-12
Ac-227	Pa-231	1.000E+00	2.057E-01	1.875E+00	4.403E-02	5.512E-13
Ac-227	U-235	1.000E+00	1.463E-06	2.402E-04	8.315E-05	1.741E-16
Ac-227	∑DOSE(j)		1.294E+01	5.286E+00	4.413E-02	3.601E-12
Pa-231	Pa-231	1.000E+00	4.312E+00	2.768E+00	3.468E-02	0.000E+00
Pa-231	U-235	1.000E+00	4.450E-05	6.141E-04	7.381E-05	0.000E+00
Pa-231	∑DOSE(j)		4.312E+00	2.768E+00	3.475E-02	0.000E+00
Pb-210	Pb-210	1.000E+00	2.490E+01	1.410E+01	5.614E-02	0.000E+00
Pb-210	Ra-226	1.000E+00	6.238E-01	7.483E+00	9.589E-01	0.000E+00
Pb-210	Th-230	1.000E+00	9.673E-05	1.972E-02	1.040E-01	0.000E+00
Pb-210	U-234	1.000E+00	2.274E-10	6.056E-07	2.018E-05	0.000E+00
Pb-210	U-238	1.000E+00	1.339E-16	4.456E-12	1.086E-09	0.000E+00
Pb-210	∑DOSE(j)		2.553E+01	2.161E+01	1.119E+00	0.000E+00
Ra-226	Ra-226	1.000E+00	3.056E+02	2.274E+02	1.185E+01	0.000E+00
Ra-226	Th-230	1.000E+00	6.623E-02	1.198E+00	2.747E+00	0.000E+00
Ra-226	U-234	1.000E+00	1.968E-07	5.208E-05	5.793E-04	0.000E+00
Ra-226	U-238	1.000E+00	1.386E-13	4.956E-10	3.450E-08	0.000E+00
Ra-226	∑DOSE(j)		3.057E+02	2.286E+02	1.459E+01	0.000E+00
Th-230	Th-230	1.000E+00	1.129E+01	1.053E+01	3.741E+00	0.000E+00
Th-230	U-234	1.000E+00	5.020E-05	8.220E-04	8.728E-04	0.000E+00
Th-230	U-238	1.000E+00	4.717E-11	1.144E-08	5.987E-08	0.000E+00
Th-230	∑DOSE(j)		1.129E+01	1.053E+01	3.742E+00	0.000E+00
U-234	U-234	1.000E+00	4.734E+00	3.029E+00	3.610E-02	0.000E+00
U-234	U-238	1.000E+00	6.661E-06	9.013E-05	1.029E-05	0.000E+00
U-234	∑DOSE(j)		4.734E+00	3.029E+00	3.611E-02	0.000E+00
U-235	U-235	1.000E+00	1.131E+00	7.630E-01	1.766E-02	0.000E+00
U-238	U-238	1.000E+00	8.214E+00	5.399E+00	9.354E-02	0.000E+00

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+01	1.000E+02	1.000E+03
Ac-227	Ac-227	1.000E+00	2.200E+00	6.246E-01	7.481E-06	0.000E+00
Ac-227	Pa-231	1.000E+00	0.000E+00	3.191E-01	1.819E-02	3.141E-17
Ac-227	U-235	1.000E+00	0.000E+00	3.865E-05	3.415E-05	6.639E-19
Ac-227	∑S(j):		2.200E+00	9.436E-01	1.823E-02	3.207E-17
Pa-231	Pa-231	1.000E+00	2.200E+00	1.508E+00	5.036E-02	8.696E-17
Pa-231	U-235	1.000E+00	0.000E+00	3.191E-04	1.067E-04	1.859E-18
Pa-231	∑S(j):		2.200E+00	1.508E+00	5.047E-02	8.882E-17
Pb-210	Pb-210	1.000E+00	3.420E+01	2.075E+01	2.310E-01	6.754E-21
Pb-210	Ra-226	1.000E+00	0.000E+00	1.034E+01	3.889E+00	8.384E-11
Pb-210	Th-230	1.000E+00	0.000E+00	2.557E-02	4.150E-01	4.626E-01
Pb-210	U-234	1.000E+00	0.000E+00	7.433E-07	8.028E-05	1.104E-04
Pb-210	U-238	1.000E+00	0.000E+00	5.169E-12	4.305E-09	8.302E-09
Pb-210	∑S(j):		3.420E+01	3.112E+01	4.535E+00	4.627E-01
Ra-226	Ra-226	1.000E+00	4.890E+01	3.718E+01	3.154E+00	6.086E-11
Ra-226	Th-230	1.000E+00	0.000E+00	1.852E-01	7.209E-01	7.432E-01
Ra-226	U-234	1.000E+00	0.000E+00	7.697E-06	1.518E-04	1.774E-04
Ra-226	U-238	1.000E+00	0.000E+00	6.983E-11	9.016E-09	1.334E-08
Ra-226	∑S(j):		4.890E+01	3.736E+01	3.875E+00	7.434E-01
Th-230	Th-230	1.000E+00	4.890E+01	4.888E+01	4.870E+01	4.696E+01
Th-230	U-234	1.000E+00	0.000E+00	3.666E-03	1.136E-02	1.121E-02
Th-230	U-238	1.000E+00	0.000E+00	4.870E-08	7.780E-07	8.427E-07
Th-230	∑S(j):		4.890E+01	4.888E+01	4.871E+01	4.697E+01
U-234	U-234	1.000E+00	4.890E+01	3.352E+01	1.121E+00	1.969E-15
U-234	U-238	1.000E+00	0.000E+00	9.504E-04	3.180E-04	5.589E-18
U-234	∑S(j):		4.890E+01	3.353E+01	1.122E+00	1.974E-15
U-235	U-235	1.000E+00	2.200E+00	1.508E+00	5.047E-02	8.882E-17
U-238	U-238	1.000E+00	4.890E+01	3.353E+01	1.122E+00	1.974E-15

BRF(i) is the branch fraction of the parent nuclide.

RESCALC.EXE execution time = 24.17 seconds

APPENDIX F

NATURAL BACKGROUND CONCENTRATIONS
OF RADIONUCLIDES IN SOIL

APPENDIX F

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Natural Background Concentrations of Radionuclides in Soil

F.0 Introduction

The natural background data are taken from the draft report, Preoperational Radiological Environmental Monitoring Program- Interim Results 1979-1980, prepared by Woodward-Clyde Consultants (PRL, 1980). A total of 62 samples were taken in and around the mill site in May and August of 1979 (see Table F-1). The samples were taken in a radial grid extending out from the center of the site. A background sample location was defined as a 100-m^2 area where ten 0.5 kg samples were taken to a depth of 5 cm. These ten samples were then composited into one single sample for that location, split, with one half of the sample sent off to the lab for analysis and the other half stored for possible future reference. Results for natural uranium (U-nat), Th-230, and Ra-226 are used in this analysis.

Table F-1 Preoperational Background Sample Data

	U-nat		Th-230		Ra-226	
Location	Conc. (pCi/g)	Error. (pCi/g)	Conc. (pCi/g)	Error. (pCi/g)	Conc. (pCi/g)	Error. (pCi/g)
1	0.32	0.12	0.45	0.21	0.18	0.05
2					0.31	0.03
3					0.18	0.03
4	0.36	0.10	0.66	0.41	0.23	0.07
5					0.26	0.03
6					0.21	0.02
7					0.60	0.04
8					0.35	0.03
9					0.16	0.02
10	0.37	0.15	0.47	0.21	0.18	0.05
11					0.23	0.03
12					0.10	0.02
13					0.15	0.04
14					0.23	0.04
15					0.18	0.03
16					0.15	0.02
17					0.16	0.02
18					0.23	0.03
19					0.25	0.03
20					0.69	0.04
21					0.40	0.04
22					0.43	0.04
23					0.30	0.03
24					0.18	0.03
25	0.74	0.54	0.94	0.79	0.00	0.02
26	0.24	0.15	0.15	0.08	0.07	0.02
27					0.48	0.04
28					0.19	0.02
29					0.18	0.02
30	0.48	0.34	0.29	0.17	0.33	0.10
31					0.10	0.03
32					1.23	0.05
33					0.16	0.03
34					0.17	0.03
35					0.57	0.04
36					0.99	0.06
37					0.36	0.04
38					1.37	0.72
39					0.51	0.04
40					0.40	0.04
41					0.22	0.03
42					0.20	0.03
43					0.16	0.02
44	0.59	0.11	0.48	0.20	0.31	0.09
45					0.48	0.04
46					0.36	0.04
47					0.21	0.03
48					0.54	0.04
49					0.46	0.04
50					0.38	0.03
51					0.26	0.03
52	0.56	0.19	1.30	0.80	0.27	0.08
53					0.27	0.04
54					1.46	0.39
55					0.21	0.02
56					0.13	0.02
AP-1	1.56	0.20	1.20	0.40	0.62	0.19
AP-2	0.41	0.14	0.28	0.14	0.22	0.07
AP-3	0.37	0.13	0.46	0.20	0.19	0.06
AP-4	0.35	0.09	0.37	0.18	0.19	0.06
C-1	0.31	0.09	0.30	0.15	0.19	0.06
C-2	0.42	0.15	0.25	0.15	0.20	0.06

F.l Natural Background Sample Statistics

Both the descriptive statistics and ordinal statistics of the 62 background samples are presented in Table F-2. Of the 62 samples, only 14 were analyzed for U-nat or Th-230. The descriptive statistics show the number of samples in each data set, mean, and standard deviation as well as variance and skewness. The ordinal statistics present the range, maximum and minimum value, 10th, 25th, 75th and 95th percentiles and the interquartile range for the three data sets.

Table F-2 Descriptive and Ordinal Statistics

	U-nat	Th-230	Ra-226
Count (n)	14	14	62
Mean	0.51	0.54	0.34
Geometric Mean	0.45	0.45	0.25
95th Percentile C.I.	0.17	0.19	0.07
Standard Deviation	0.33	0.36	0.29
Variance	0.11	0.13	0.08
Skewness	2.83	1.26	2.46
Kurtosis	8.97	0.53	6.49
Mean + Std. Dev.	0.84	0.90	0.63
Minimum	0.24	0.15	0.00
Maximum	1.56	1.3	1.46
Range	1.32	1.15	1.46
10th Percentile	0.31	0.26	0.15
25th Percentile	0.35	0.29	0.18
50th Percentile (Median)	0.39	0.46	0.23
75th Percentile	0.54	0.62	0.40
90th Percentile	0.70	1.12	0.60
95st Percentile	1.07	1.24	0.97
Interguartile Range (I O R)	0.19	0.32	0.22

F.2 Analysis of Distribution

The distribution of measured values has been analyzed following the EPA recommended procedure and, where appropriate, use of the EPA software, Data Quality Evaluation Statistical Toolbox (DataQUEST) (EPA QA/G-9D). An *a priori* screening of the data was performed to assure that no outliers were included in the analysis (see Table F-3).

Any observation that is 4 or 5 times as large as the rest of the data is considered suspect (EPA 1989). Conservatively for this test, outliers are defined as maximum values greater than three times the next highest value. If a datum value fails the *a priori* test then it must be removed from the data set and explained. No data values were found to be outliers.

Table F-3 A *Priori* Screening

Parameter	Maximum Value	Next Maximum Value	Multiplicative Factor	Results
U-Nat	1.56	0.74	2.1	Pass
Th-230	1.30	1.2	1.1	Pass
Ra-226	1.46	1.37	1.1	Pass

A Determination of Percent Non-detects Analysis was performed on the data. If the percentage of non-detects was less than 15 percent, the non-detect was replaced by the detection limit divided by two. If the percentage of non-detects was found to be greater than 15 percent then the distribution was considered non-parametric and a distribution was not performed (EPA 1989, 1992). As shown in Table F-4 there was not a determination of non-parametric distribution.

Table F-4 Percentage of Non-Detects

Parameter	Number of Records	Number of Non-Detects	Percentage of Non-Detects	Results
U-Nat	14	0	0.00	Pass
Th-230	14	0	0.00	Pass
Ra-226	62	1	0.02	Pass

Histograms were then prepared for the U-nat, Th-230, and Ra-226 data sets as shown in Figures F-1, F-2, and F-3 and Figures F-4, F-5, and F-6 for the natural log (ln)- transformed data. While the data are skewed to the high concentration end of the distribution, it is not apparent from the histograms that the data are log-normally distributed.

A series of tests was then conducted to ascertain whether the data follow a parametric distribution. For these data sets, the parametric tests were restricted to testing for normality using the log transformed and non-transformed raw data. Normally-distributed data usually have a coefficient of variation of less than 1.0. The results, as shown in Table F-5, indicate that normality cannot be ruled out for all constituents, using the raw data and log-transformed data sets. The Coefficient of Variation was calculated using the DataQUEST software.

Table F-5 Coefficient of Variation Analysis

Parameter	Standard Deviation	Mean	Coefficient of Variation	Results
U-Nat (raw data)	0.33	0.51	0.65	Pass
U-Nat (log transformed data)	0.46	-0.80	-0.57	Pass
Th-230 (raw data)	0.36	0.54	0.66	Pass
Th-230 (log transformed data)	0.62	-0.79	-0.78	Pass
Ra-226 (raw data)	0.29	0.34	0.85	Pass
Ra-226 (log transformed data)	0.75	-1.34	-0.56	Pass

Almost 100% for the area within a normal curve lies within +/- five standard deviations from the mean. The Studentized Range Test for Normality was developed using this fact. This test compares the range of the sample divided by the standard deviation(s) to a critical value range. If the value is outside the range, the test fails. The results of this test are given in Table F-6 where all data sets passed with the exception of the log- transformed Ra-226 data set. Therefore the Ra-226 log transformed data may not be described as lognormal. The other results indicate there is not enough evidence to reject the assumption of normality with a 5 % significance level. The Studentized Range Test was performed using the DataQUEST software.

Table F-6 Studentized Range Test Analysis

Parameter	Critical Values		W/S	Results
	Maximum	Minimum		
U-Nat (raw data)	2.92	4.09	3.99	Pass
U-Nat (log transformed data)	2.92	4.09	4.05	Pass
Th-230 (raw data)	2.92	4.09	3.22	Pass
Th-230 (log transformed data)	2.92	4.09	3.50	Pass
Ra-226 (raw data)	3.98	5.53	5.09	Pass
Ra-226 (log transformed data)	3.98	5.53	6.30	Fail

It has been shown that a small degree of skewness (between -1 and +1) is not likely to affect the results of statistical tests based on an assumption of normality. However, if the coefficient of skewness is larger than 1 (in absolute value) and the sample size is small (e.g. < 25), statistical research has shown that standard normal theory-based tests are much less powerful than when the skewness is less than 1 (Gayen, 1949). Therefore, it is considered a failure of the test for normality if the coefficient of skewness exceeds 1. The results of the Coefficient of Skewness Test are shown in Table F-7. All tests failed at a significance level of 5 percent with the exception ofthe log-transformed Th-230 and Ra-226 data sets. Therefore the log-transformed Th-230 and Ra-226 data sets may be described as lognormal.

Table F-7 Coefficient of Skewness Test

Parameter	Coefficient of Skewness	Results
U-Nat (raw data)	2.5	Fail
U-Nat (log transformed data)	1.4	Fail
Th-230 (raw data)	1.1	Fail
Th-230 (log transformed data)	0.2	Pass
Ra-226 (raw data)	2.4	Fail
Ra-226 (log transformed data)	-0.8	Pass

The Shapiro-Wilk Test of Normality is based on the premise that, if a data set is nonnally distributed, the ordered values should be highly correlative with the corresponding quantiles taken from a normal distribution (Shapiro-Wilk, 1965). In particular, the Shapiro-Wilk Test of Normality gives substantial weight to the evidence of non-normality in the tails of a distribution, where the robustness of statistical tests based on the normality assumption is the most severely affected (EPA, 1992). It is applied to data sets with fewer than 50 data points.

The Shapiro-Wilk test statistic will tend to be large (close to 1) when the data is normally distributed. Only when the plotted data shows significant bends or curves will the test statistic be small. The Shapiro-Wilk Test of Normality is considered to be one of the best available tests of normality (Miller, 1986; Madansky, 1988). The results shown in Table F-8 reject the assumption of normality at the 5% significance level for the raw and log- transformed data sets for U-nat and the raw data set for Th-230. The Shapiro-Wilk Test of Normality was performed using the DataQUEST software.

Table F-8 Shapiro-Wilk Test of Normality (n < 50)

Parameter	Shapiro-Wilk Test Statistic	Table Value	Results
U-Nat (raw data)	0.649	0.874	Non-normality detected at 5.0 % significance level
U-Nat (log transformed data)	0.872	0.874	Non-lognormality detected at 5.0 % significance level
Th-230 (raw data)	0.834	0.874	Non-normality detected at 5.0 % significance level
Th-230 (log transformed data)	0.956	0.874	Not enough evidence to reject the assumption of lognormailty with a 5.0% significance level

Geary's normality test is another commonly used test for data sets having a minimum of 50 data points. The Ra-226 raw and log-transformed data sets showed non-normality at the *5%* confidence limit as shown in Table F-9. The Geary's Test was performed using the DataQUEST software.

Table F-9 Geary's Test (n > 50)

Parameter	Geary's Test Statistic	Table Value	Results
Ra-226 (raw data)	-4.722	1.645	Non-normality detected at 5.0 % significance level
Ra-226 (log transformed data)	-3.315	1.645	Non-lognormality detected at 5.0 % significance level

The Filliben's Statistic is also considered a powerful tool for detecting non-normality. When applied to the data sets, all but the log-transformed Th-230 data showed non- normality at the 5% significance level as shown in Table F-10. The test could not reject the assumption of normality for the log-transformed data at the 5% confidence level. The Filliben's Statistic was performed using the DataQUEST software.

Table F-10 Filliben's Statistic

Parameter	Filiiben's Test Statistic	Table Value	Results
U-Nat (raw data)	0.786	0.934	Non-normality detected at 5.0 % significance level
U-Nat (log transformed data)	0.922	0.934.	Non-lognormality detected at 5.0 % significance level
Th-230 (raw data)	0.916	0.934	Non-normality detected at 5.0 % significance level
Th-230 (log transformed data)	0.979	0.934	Not enough evidence to reject the assumption of lognormailty with a 5.0% significance level
Ra-226 (raw data)	0.838	0.981	Non-normality detected at 5.0 % significance level
Ra-226 (log transformed data)	0.938	0.981	Non-lognormality detected at 5.0 % significance level

F.3 Summary and Recommendation

The analyses of distributions in Section F.2 indicate that the data are probably not normally or log-normally distributed. Therefore the distribution is non-parametric. As such, one cannot use a formula to develop a background value that corresponds to a specified Type I and Type II error rate.

The raw data and statistical parameters have been given in Table F-2, along with the calculated percentiles. The mean concentrations are on the low end of the range of natural background concentrations found in the United States. The standard deviations of the data are also very small in absolute value. In fact, the standard deviations of the raw data in the U-nat, Th-230, and Ra-226 data sets suggest that the analytical counting errors are a significant fraction of the standard deviation. This presents a practical problem in that the Type I error rate (false positives) may be unacceptably high due to laboratory uncertainty if the cleanup limit is low.

Site background concentrations of 0.51, 0.54 and 0.34 pCi/g, respectively, are proposed for U-nat, Th-230, and Ra-226. This *roughly* corresponds to the mean for each data set and is consistent with the mean background concentrations within the United States.

F.4 References

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Figure F-1 U-Nat Histogram
n=14

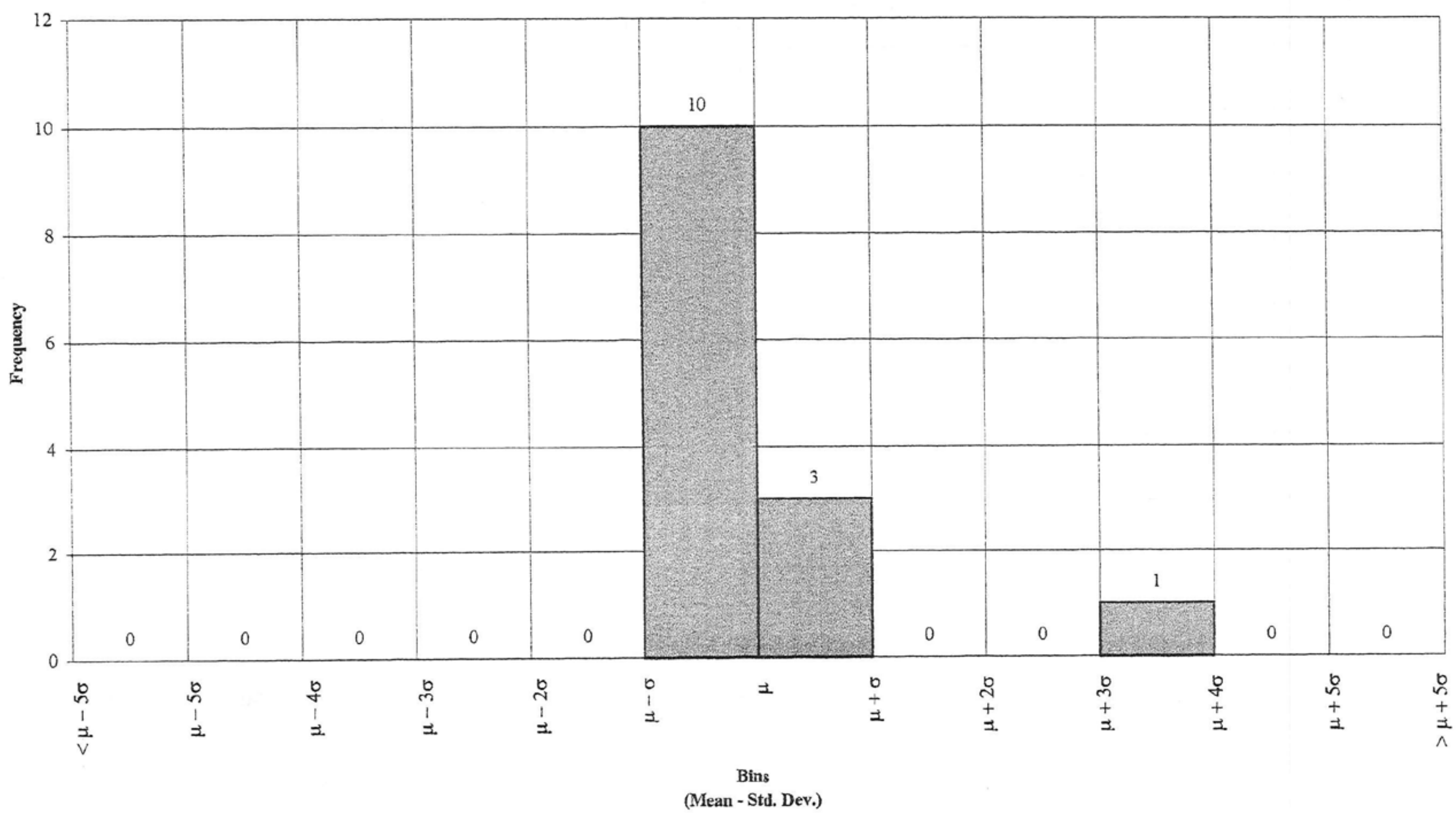

Figure F-4 Log Transformed U-Nat Data Histogram
n=14

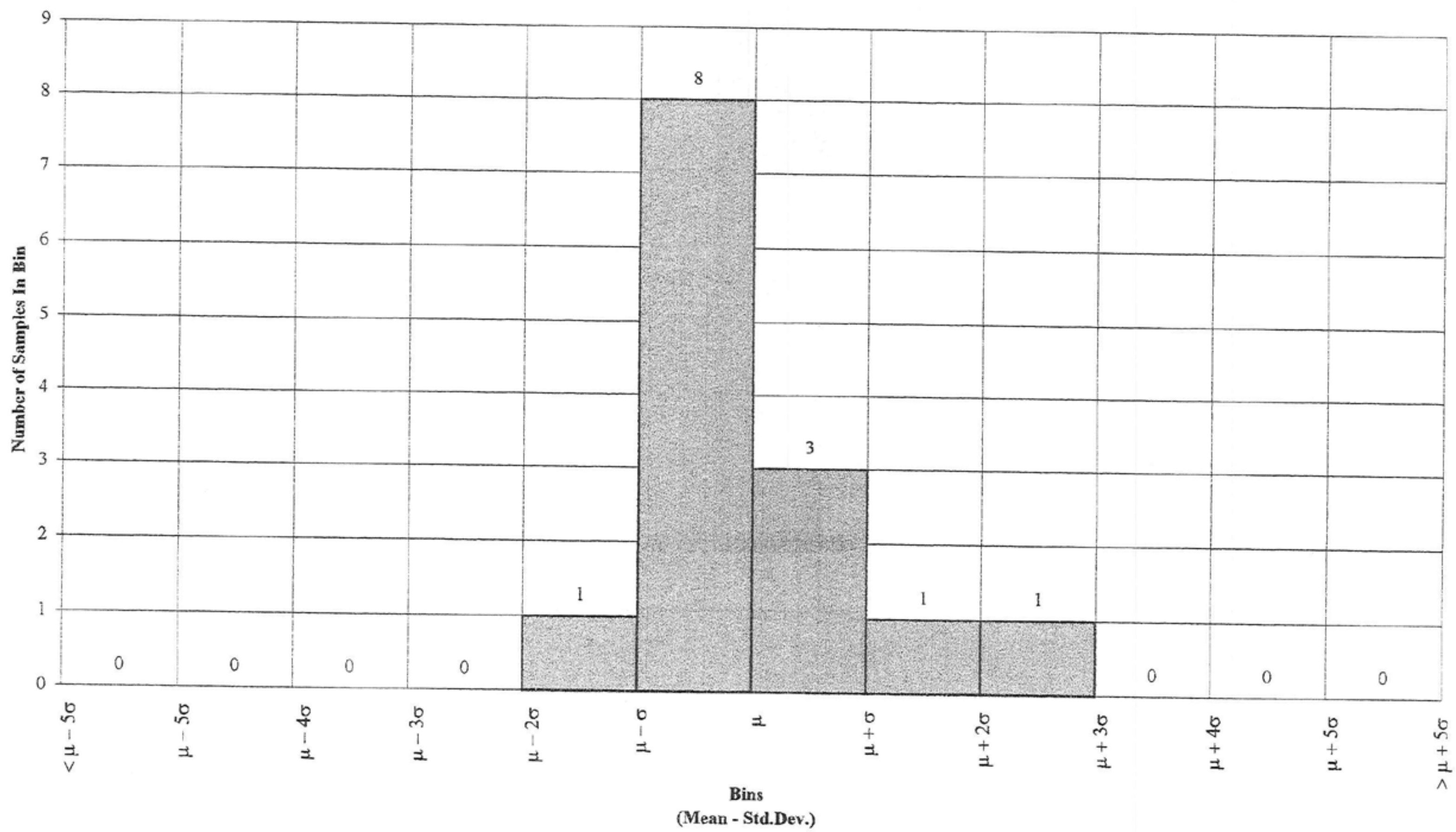

Figure F-3 Ra-226 Histogram
n=62

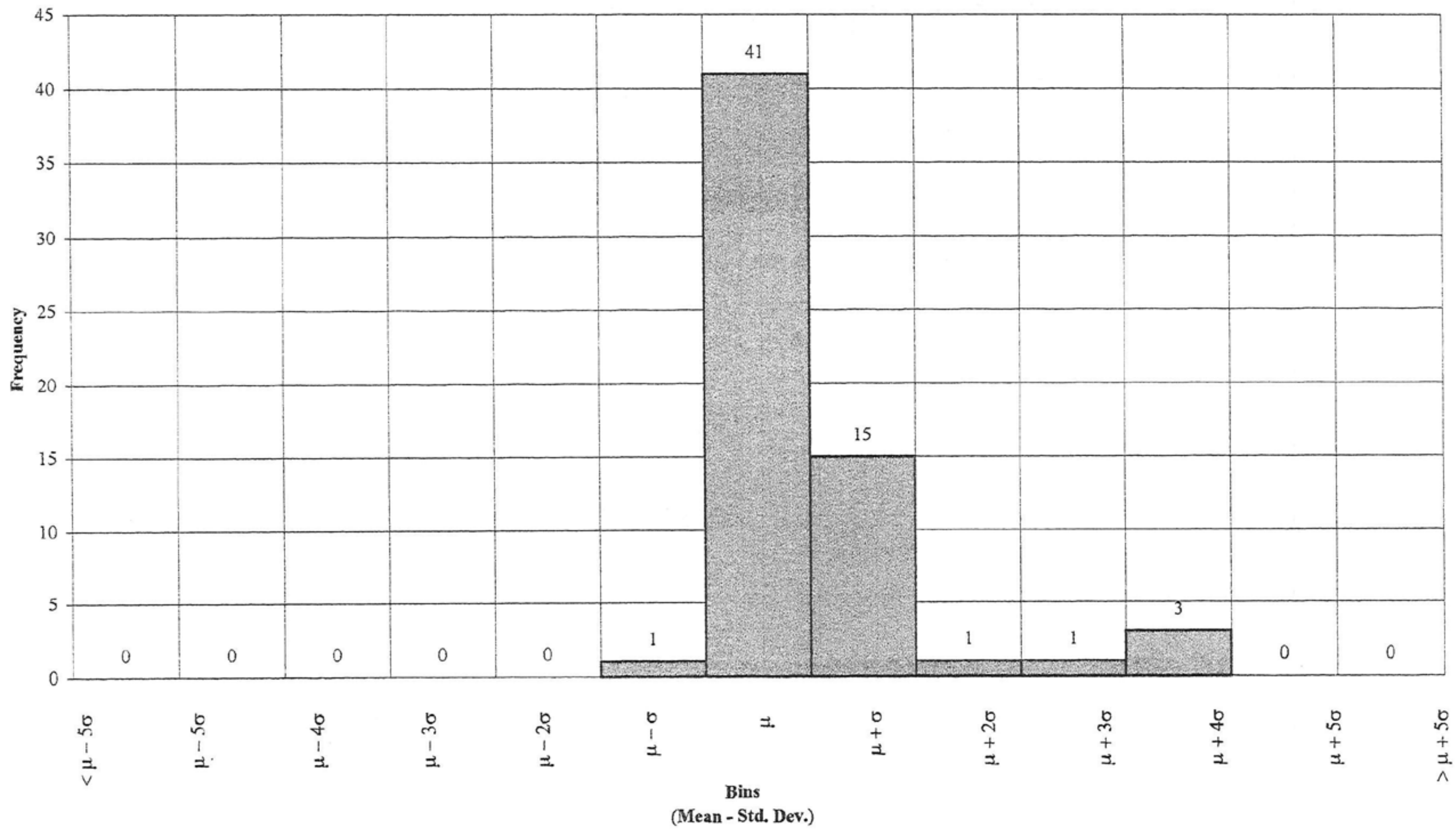

Figure F-4 Log Transformed U-Nat Data Histogram
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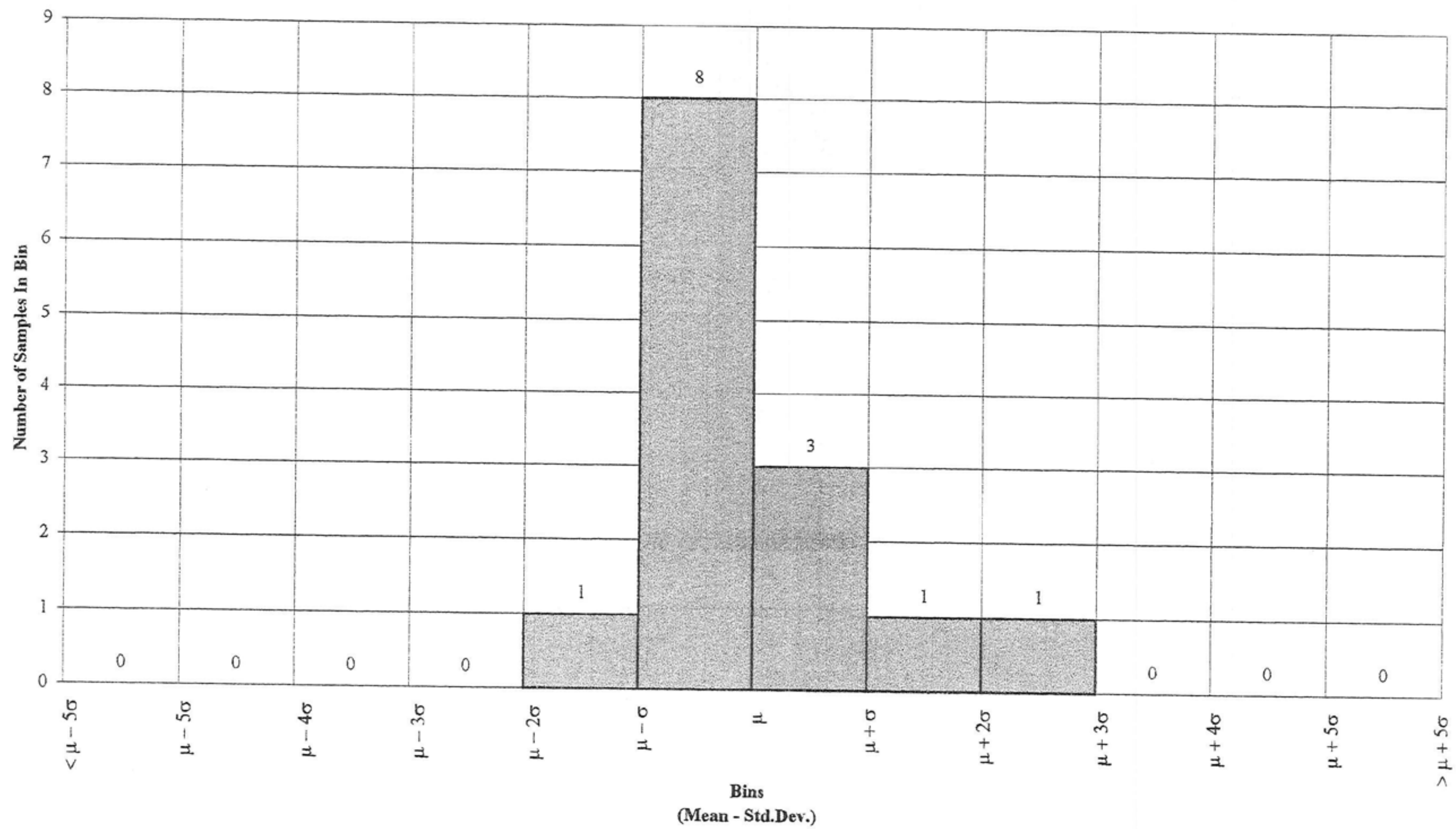

Figure F-5 Log Transformed Th-230 Data Histogram
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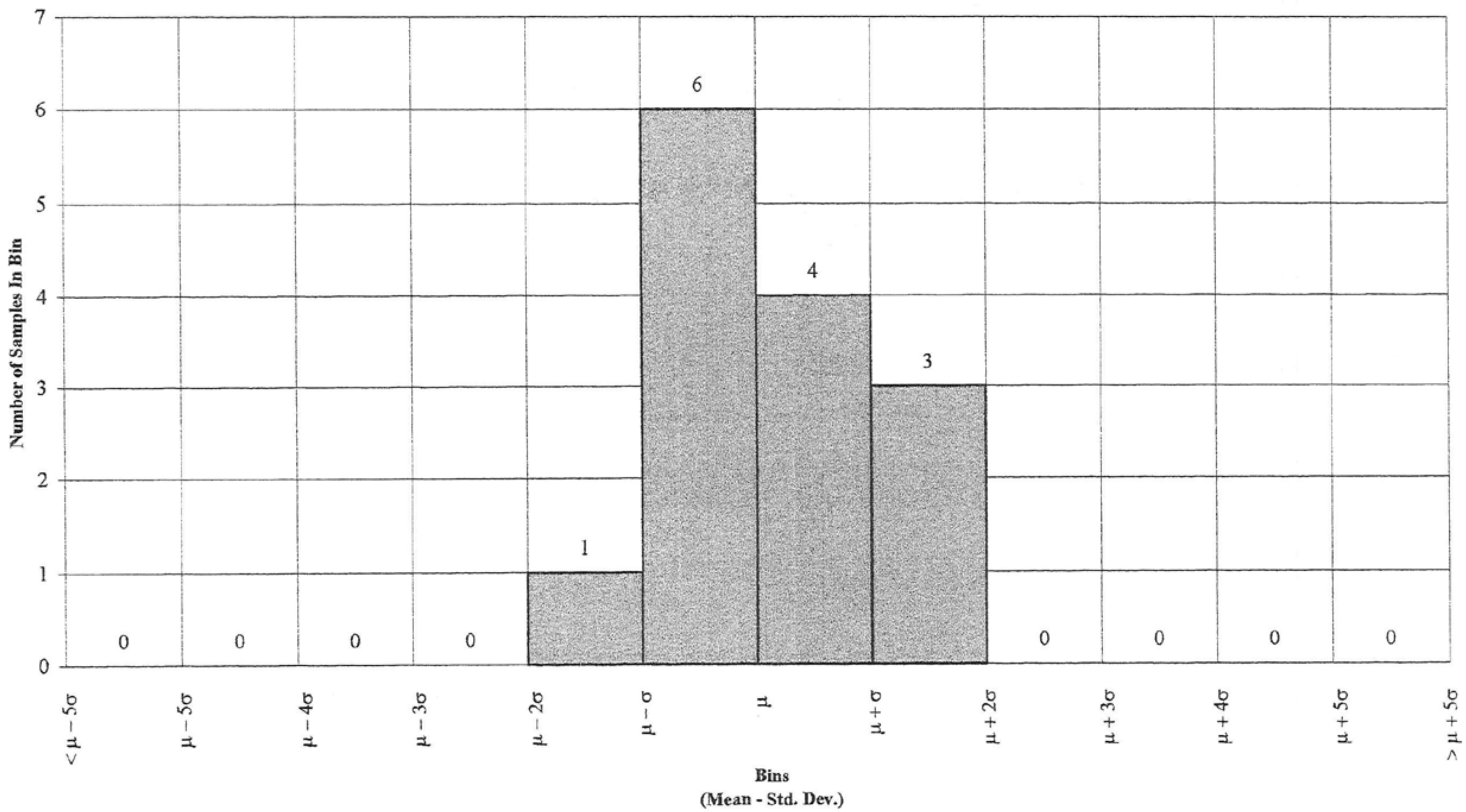
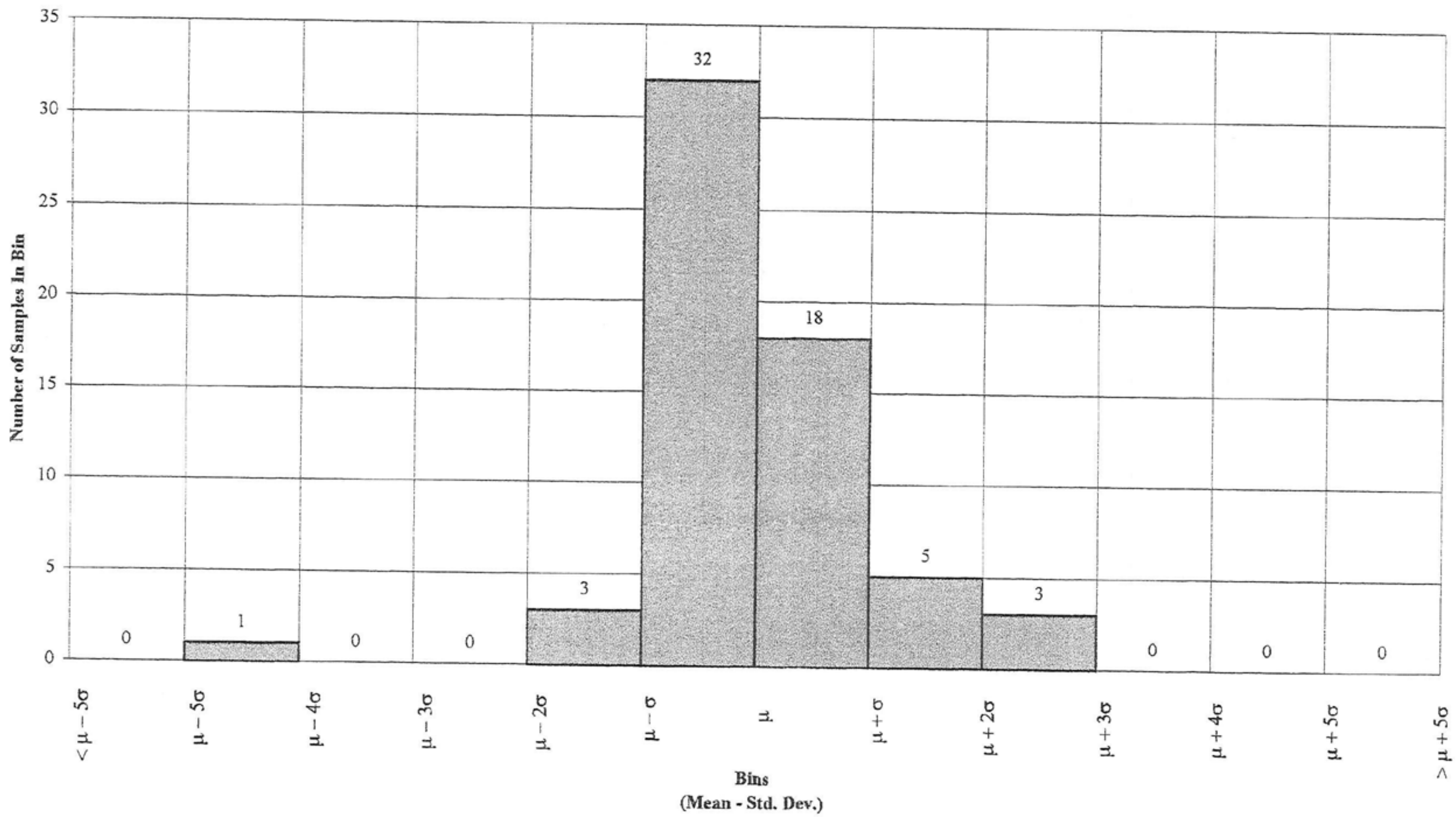


Figure F-6 Log Transformed Ra-226 Data Histogram
n=62



APPENDIX G

DERIVATION OF SURFACE CONTAMINATION LIMITS

APPENDIX G

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TABLES

ATTACHMENTS

Appendix G
Derivation of Surface Contamination Limits

G.0 Introduction

RESRAD-Build 3.0 (ANL, 1994; NRC, 2000) was used to evaluate the dose to industrial workers occupying the buildings on the site currently within the radiologically restricted area. The future use for these buildings will likely be associated with the recreational needs of the local area. Possibilities include boat maintenance, refurbishing, and storage. The existing electrical power facilities could provide power to these buildings as well as to the local community.

The most restrictive exposure scenario related to these buildings is for workers, such as mechanics, hired to do boat service or repair. It is assumed the current offices within the buildings will remain to serve as administrative and support facilities for the workers.

The principal constituents in the surface contamination should reflect the process stream. The milling operations consist of the Ore Hopper and Conveyor Feed, SAG Mill, and Solvent Extraction Areas, where the radionuclide mix should be similar to ore. The radionuclide mix in the yellowcake drying and packaging area should consist of natural uranium that has been purified within the last 30 years.

The approach used was to calculate the radiological dose to industrial workers, assuming that the surface contamination was made up exclusively of one constituent. As will be seen, the worst-case model assumed all of the contamination to be uranium. The total gross surface contamination limit was then based on the presence of radionuclides that would result in a maximum dose to the workers of 25 mrem/y. This value is conservative compared to the Benchmark Approach and is consistent with 10 CFR Part 20, §20.1402.

G.1 Current Contamination

Low levels of surface contamination are known to exist generally throughout the buildings. The levels are considered low and less extensive when compared to those of uranium mills that were operated for long periods of time. Measured total gross alpha levels up to 796 dpm/100 cm^2 have been measured recently in the processing areas of the plant. Prior surface contamination data show that individual removable fractions of contamination are limited to approximately 8 percent of the total. Once the process equipment is removed from the buildings, a thorough cleaning of the contaminated building surface areas will be performed, rendering the surface cleanliness and contamination levels comparable to and possibly below current levels.

G.2 Parameter Justification

The exposure pathways considered in the industrial occupancy scenario are external exposure due to the source, inhalation of airborne radioactive material, and inadvertent ingestion of radioactive material. The parameter analysis is based on guidance provide in NUREG-5512 Volumes 1 and 3 (NRC, 1992, NRC, 1999) and NRC 2000. The selected parameter values, along with default parameter values, are provided in Table G-1. The bases for selecting parameter values are discussed below.

The default condition assumes that the maximum dose is received during the first year of occupancy by assuming the removable fraction is linearly removed within 365 days. We believe that this is reasonable but conservative for this situation since the levels of removable contamination will decrease over time in some areas. A build-up of dirt, grease, oil, paint, or other coverings may also occur which will reduce airborne concentration levels. The occupancy time was assumed to be 250 days per year, 8 hours per day over the 365-day exposure period. The fraction of the exposure period that a worker spends indoors is then (250 *8)/(365 *24) = 0.228. The workers were assumed to spend the entire work day in the contaminated area. A breathing rate of $18m^3$/day was used since it is representative of active workers.

Several room sizes and ceiling heights were evaluated. The calculated dose, however, is not highly sensitive to the room size but is highly dependent on ceiling height. An exchange rate of slightly less than 1 change per hour is normal for homes in the U.S. Reported studies of homes show maximum air exchange rates for homes average slightly less than one per hour and are typically less than 3 air exchanges per hour (NRC, 2000). Since the buildings are not built to have low air exchange rates, and it is probable that the large doors would remain open during occupancy in reasonably warm weather, an air exchange rate of 2 air exchanges per hour was used in the model.

The model provides for a plane source or volume source. The source selected for the model was assumed to be a uniformly contaminated floor of size equal to the room size. It is unlikely that the contaminated area is larger than the floor area. Should this not be the case, the characterization surveys will reveal it and the calculated average limits will be reduced by an appropriate area factor. The results will show that the airborne activity is the predominant dose pathway to the occupants. It is probable that the resuspended particulate will arise from the contaminated floor rather than the walls or ceiling. For these reasons, it is believed that considering only the floor to be contaminated is a reasonable approach for modeling the dose using RESRAD-Build. The receptor was placed in the center of the floor and the total effective dose equivalent (TEDE) calculated at a height of one meter above the floor.

The deposition velocity for indoor air has been shown to vary considerably. RESRAD- Build assumes a log uniform probability distribution with a range from 2.7E-6 m/s to 2.7E-3 m/s. A sensitivity analysis shows that the TEDE varied less than three percent with changes in this parameter. Therefore a conservative value of 0.0l m/s was selected. Similarly, the results were influenced by less than three percent with changes in the resuspension rate. RESRAD-Build assumes a log uniform probability distribution ranging from 2.8E-10 s^{-1} to 1.4E-5 s^{-1}. A value of 5E-7 s^{-1} was selected for this parameter.

Preliminary site characterization data indicate removable fractions of less than 8 percent. Since an extensive survey and cleaning effort will occur prior to the release of the sites, we believe that 20 percent is conservative for these buildings.

Table G-1 Parameter for the Industrial Use Scenario

RESRAD Building Parameter	Selected Value
External dose rate factor from surfaces (mrernlh per dpm/100 cm^2	FG Report No. 12
Inhalation CEDE factor (mrernlpCi inhaled)	FG Report No. 11
Ingestion CEDE factor (mrem/pCi ingested)	FG Report No. 11
Exposure period (days)	365
Fraction of time that exposure occurs during the exposure period (called indoor fraction in RESRAD-Build)	0.228
Time fraction of receptor	1
Deposition velocity (m/s)	0.01
Resuspension rate (1/s)	5.0E-07
Volumetric breathing rate (m^3/day)	18
Effective transfer rate for ingestion of removable contamination from surfaces to hands, from hands to mouth {m^2/h}	l.0E-04
Fraction of Removable Contamination	20%
Size ofRoom (m * m * m)	10*10*10
Loose Fraction Removal Time (days)	365
Air Exchange Rate (1/h)	2
Source Geometry (m * m * m)	10 * 10 * 0
Radon Release Fraction	0.3
Fraction of time at work subject to exposure	1
Direct Ingestion Rate	0

The radon release fraction is based on the emanating fraction for radon in mill tailings, which typically ranges from 0.1-0.3. Since the contamination layer is very thin, we believe that a larger fraction of the Rn-222 will be released. The radon release rate for Rn-219 is probably closer to zero since the half-life is less than 1 minute. However, the low abundance of the U-235 decay chain makes the TEDE from the U-235 decay chain negligible. We have therefore used 0.3 as the emanation fraction for radon.

G.3 Radionuclide Source Term

RESRAD-Build considers only the long-lived radionuclides (half-lives longer than 0.5 years). For short-lived progeny, the code automatically includes the in-growth and corresponding dose contributions with the parent. The two source terms of interest for the buildings are yellowcake and ore (or process material). For ore (or process material) the secular equilibrium was assumed down to radon. It was assumed that 30 percent of the Rn-

222 escaped from the solid matrix for ore. No release of the Rn-219 in the U-235 series was assumed since gaseous diffusion out of the matrix is unlikely because the half life of Rn-219 is less than one second.

The natural activity abundance of natural uranium is 2.2 percent U-235, and 48.9 percent each of U-238 and U-234. It is desirable to measure surface contamination for these facilities as gross alpha/100 cm^2. We therefore have derived surface activity limits by first calculating, using RESRAD-Build, a TEDE corresponding to 1,000 dpm gross alpha/100 cm^2 For the yellowcake-contaminated areas the in-growth of alpha-emitting progeny can be shown to be negligible, thus a gross alpha contamination level of 1,000 dpm/100 cm^2 would result in contributions of 489 dpm/100 cm^2, 489 dpm/1 00 cm^2, and 22 dpm/100 cm^2 from U-238, U-234, and U-235 respectively. These activities were used as input into RESRAD-Build for yellowcake contamination.

The determination of the activities for the long-lived radionuclides in uranium ore is more difficult as shown below. The alpha emitting radionuclides from uranium ore are given in Table G-2 below. Only the radionuclides with halflives longer than 0.5 year are considered. The alpha decays of each radionuclide and short-lived progeny are listed in the second column of Table G-2. The value for Ra-226 was obtained by assuming that 70 percent of the Rn-222 remained in the solid matrix. Thus only 70 percent of the alpha emissions from the Rn-222 and progeny (Po-218 and Po-214) will be observed. Similarly, only 70 percent of the alpha particles from the Pb-210 progeny, Po-210, will be observed.

Table G-2 Alpha Emissions from the Parent Decay of Long-Lived Radionuclides in Uranium Ore

Decay Chain	Radionuclide	Alpha emissions per parent decay
D_{238}	U-238	1
	U-234	1
	Th-230	1
	Ra-226	3.1
	Pb-210	0.7
D_{235}	U-235	1
	Pa-231	1
	Ac-227	5

In order to calculate the activity concentrations of the radionuclides for input into the RESRAD-Build code, we have used the following relationship: $D_{235} + D_{238} = 1000$ dpm/100 cm^2

Where: D_{235} and D_{238} are the emission rate of alphas from the U-235 and U-238 decay chains per 100 cm^2, respectively. Using data from Table G-2 and the natural activity abundance ratio for U-235/U-238 (0.022/0. 0489), the equation can be rewritten using the following steps as:

(1) $(D_{235} * 7) + (D_{238} * 6.8) = 1000$

(2) $D_{235} = (0.022/0.489) * D'_{238}$

(3) $[(0.022/0.489) * 7 * D_{238}] + (6.8 * D_{238}) = 1000$ dpm/100 cm^2

Where: D_{235} is the disintegration rate of U-235 per 100 cm^2 and D_{238} is the disintegration rate of U-238 per 100 cm^2. Solving for D_{238} and using the natural abundance ratios, $D_{238} =$ 140 dpm/100 cm^2 and $D_{235} = 6.3$ dpm/1 00 cm^2.

The source term input for uranium ore is provided in Table G-3, using the calculated activities for the parents of the decay chain, U-238 and U-235, and the assumed radon release rates as discussed above.

Table G-3 Surface Parent Activities of Long-Lived Radionuclides of Uranium Ore that Result in a Gross Alpha Activity of 1,000 dpm/100 cm^2

Radionuclide	Activity (dpm/100 cm^2
U-238	140
U-234	140
Th-230	140
Ra-226	140
Pb-210	98
U-235	6.3
Pa-231	6.3
Ac-227	6.3

G.4 Results

RESRAD-Build was run for rooms of various sizes where the contaminants were either yellowcake or residue having a radionuclide mix corresponding to uranium ore. In all cases, only the floor was assumed to be contaminated at 1,000 dpm/100 cm^2 (4. 5E+4 pCi/m^2). For uranium, the natural abundance ratio was assumed where the total activity for uranium was divided into 48.9 percent each for U-238 and U-234 and 2.2 percent for U-235. The results of the calculations are included in the RESRAD-Build report included at the end of this section as Attachment G-1 through G-8 and summarized in Table G-4.

Table G-4 TEDE from Industrial Worker Exposure to Surface Contamination at a Level of 1000 dpm/100 cm^2

Contaminant	Room Size LxWxH (m x m x m)	Total Effective Dose Equivalent (TEDE) (mrem)
Yellowcake	3*3*3	32.1
Yellowcake	3 * 3 * 15	6.43
Yellowcake	10*10*5	19.3
Yellowcake	100 * 100 * 15	6.44
Uranium Ore	3*3*3	35.3
Uranium Ore	3 * 3 * 15	7.11
Uranium Ore	10*10*5	21.3
Uranium Ore	100 * 100 * 15	7.3

The results show that the TEDE decreases as the volume of the room increases which is to be expected since the room air exchange rate was held constant at 2 air exchanges per hour. Currently, the mill building has very large rooms and a few small offices or rooms, all having a height of approximately 15m. Table G-4 shows that the TEDE for workers in the large rooms (approximately 100 m*100m*15 m) is almost identical to that for workers in small rooms (3m*3m*15m) as long as the ceiling height remains the same. It is likely that work areas will be 10 m * 10 m in size or larger and the desirable ceiling height of 15m would be retained. If a false ceiling were added to allow for more efficient air conditioning, a minimum ceiling height of 5 m would be expected. One or more of the smaller rooms might be used as an office where occupancy is a consideration. While the current height is approximately 15m, the ceiling might be lowered to as low as 3 m. A floor covering would probably be added thus limiting the airborne radioactive particulate. This suggests that the most conservative room model would be a room with dimensions of 10m*10m* m high for industrial workers and 3m*3m*3m for clerical or management personnel. The results shown in Table G-4 show that the TEDE remains constant as the area of room shrinks to the size of a small office (3m*3m) and depends primarily on the ceiling height. It also shows that the most limiting model (3 m*3m*3m) results in a TEDE of approximately 35 mrem/y for a contamination level of 1,000 dpm/100 cm^2 , for either yellowcake contamination or uranium ore. Thus, an average gross alpha surface contamination level of 1,000 dpm would expect to result in a maximum TEDE of 35 mrem/y.

The RESRAD-Build output shows that more than 99 percent of the TEDE arises from the inhalation pathway. Therefore the TEDE is proportional to the average contamination on the floor. Multiplying the contamination level of 1,000 dpm/100 cm^2 by 25 mrem/35 mrem, an average gross alpha surface contamination of 700 dpm/100 cm^2 should limit the TEDE to 25 mrem/y. The RESRAD-Build modeling assumed a removable fraction of 0.2, resulting in a removable limit of 140 dpm/100 cm^2. Using the Benchmark Dose of 34 mrem/y, the limits could be significantly higher. However because of ALARA considerations, it is proposed to use 700 and 140 dpm/100 cm^2 for the total and removable gross alpha limits, respectively.

G.5 Conservatism and ALARA

RESRAD-Build uses conservative dose conversation factors taken from Federal Guidance Report No. 11 (EPA, 1998). There is no user option for changing these factors. For uranium, the chemical form for inhalation is assumed by RESRAD-Build to be very insoluble (Class Y) rather than the more soluble form (Class W) or the highly soluble (Class D) chemical form. While no data are available for this site, it is probable that a large percentage of the uranium is Class W and Class D, which would reduce the TEDE significantly. Other parameters chosen conservatively include ceiling height, loose fraction removal time, and building air exchange rate.

G.6 References

ANL, 1994. RESRAD-Build: A Computer Model for Analyzing the Radiological Doses Resulting from the Remediation and Occupancy of Buildings Contaminated with Radioactive Material. ANL/EAD/LD-3. Environmental Assessment Division, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439.

EPA, 1988. Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion. Federal Guidance Report No. 11. 1988. Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C. 20460

NRC, 1992. Residual Radioactive Contamination from Decommissioning. NUREG/CR-5512 Vol. 1. 1992. U. S. Nuclear Regulatory Commission, Washington, D.C. 20555.

NRC, 1999. Residual Radioactive Contamination from Decommissioning. Parameter Analysis. Draft Report for Comment. October 1999. U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

NRC, 2000. Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes. November 2000. Prepared by Argonne National Laboratory for U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

ATTACHMENT G-1

Yellowcake RESRAD-Build Run

Room Size 3m x 3m x 3m

RESRAD-BUILD Table of Contents

RESRAD-BOILD Input Parameters ---

Number of Sources Number 1
of Receptors: Total Time 1
Fraction Inside 3.650000E+02 days
2.280000E-01

Receptor Information

Receptor	Room	x [m)	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	1.500	1.500	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship ---

Receptor	Source	Density [g/cm3)	Thickness [em]	Material
1	1	2.40E+00	0.000E+00	Concrete

Building Information

Building Air Exchange Rate: 2.00E+00 1/hr

```
 Height[m]            Air Exchanges [m3/hr]
 Area [m2]
                      *******************************
                      *                                  *
                      *                                  *
                      *                                 <=Q01: 5.40E+01
 H1:    3.000         *          Room 1                  *      Q10 : 5.40E+01
                      *     LAMBDA: 2.00E+OO             *
Area    9.000         *                                  *
                      *                                  *
                      *******************************
```

Deposition velocity: l.00E-02 [m/s] Resuspension Rate: 5.00E-07 [l/s]

Source Information

Source: 1
Location:: Room: 1 x: 1.50 y: 1.50 z: O.OO[m]
Geometry:: Type: Area Area:9.00E+00 [m2] Direction: z
Pathway ::

Direct Ingestion Rate:	0.000E+00 [1/hr]
Fraction released to air:	1.000E+00
Removable fraction:	2.000E-01
Time to Remove:	3.650E+02 [day]
Radon Release Fraction:	3.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factors		
	[dpm/m2]	Ingestion [mrem/dpm)	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-238	4.880E+04	1.212E-04	5.315E-02	7.207E-05
U-235	2.200E+03	1.203E-04	5.541E-02	4.068E-04
U-234	4.880E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	0.000E+00	4.77SE-03	5.766E-01	9.054E-05
TH-230	0.000E+00	2.468E-04	1.468E-01	9.189E-07
AC-227	0.000E+00	6.667E-03	3.027E+OO	9.730E-04
RA-226	0.000E+00	5.991E-04	3.874E-03	4.685E-03
PB-210	0.000E+00	3.275E-03	1.045E-02	4.730E-06

Assessment for Time: 1
Time =0.000E+00yr

Source Information

Source: 1

Location::	Room :	1	x:	1.50 y:	1.50	z:	0.0	[m]
Geometry::	Type: Area			Area:9.00E+00 [m2]			1.0	Direction: z

Pathway ::

Direct Ingestion Rate:	0.000E+00	[1/hr]
Fraction released to air:	1.000E+00	
Removable fraction:	2.000E-01	
Time to Remove:	3.650E+02	[day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-238	4.880E+04
U-235	2.200E+03
U-234	4.880E+04
PA-231	0.000E+00
TH-230	0.000E+00
AC-227	0.000E+00
RA-226	0.000E+00
PB-210	0.000E+00

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

		Source 1	Total
Receptor	1	3.21E+01	3.21E+01
Total		3.21E+01	3.21E+01

** RESRAD-BUILD Program Output, Version 3.1 08/08/02 10:11 Page: 15
Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.76E-03	2.33E-04	3.84E-06	3.19E+Ol	1.84E-ll	1.88E-01
Total	2.76E-03	2.33E-04	3.84E-06	3.19E+Ol	l.84E-ll	l.88E-01

** RESRAD-BUILD Program Output, Version 3.1 08/08/02 10:11 Page: 16
Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	1.48E+01	1.48E+01
U-234	2.26E-05	2.26E-05
TH-230	1.70E-10	1.70E-10
RA-226	6.55E-16	6.55E-16
PB-210	0.OOE+OO	O.OOE+OO
U-235		
U-235	6.98E-01	6.98E-01
PA-231	7.77E-05	7.77E-05
AC-227	4.16E-06	4.16E-06
U-234		
U-234	1.66E+Ol	1.66E+Ol
TH-230	1.84E-04	1.84E-04
RA-226	1.07E-09	1.07E-09
PB-210	2.61E-ll	2.61E-11

ATTACHMENT G-2

Yellowcake RESRAD-Build Run

Room Size 3m x 3m x 15m

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources Number of Receptors: Total Time Fraction Inside

1
1
3.650000E+02 days
2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [rn]	FracTime	Inhalation [m3/day)	Ingestion(Dust) [m2/hr]
1	1	1. 500	1. 500	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship ---

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+OO	0.000E+00	Concrete

Building Information

Building Air Exchange Rate: 2.00E+OO 1/hr

```
Height[m]            Air Exchanges [m3/hr]
Area [m2]
                     ******************************
                     *                                *
                     *                                *
                     *                                <=Q01: 2.70E+02
H1:  15.000          *         Room  1                *      Q10 :  2.70E+02
                     *    LAMBDA: 2.00E+00            *
Area    9.000        *                                *
                     *                                *
                     ******************************
```

Deposition velocity: 1.00E-02 [m/s]

Resuspension Rate: 5.00 E-07 [1/s]

Source Information

Source: 1

Location:: Room: 1 x: 1.50 y: 1.50 z: 0.00[m]

Geometry:: Type: Area Area:9.00E+00 [m2] Direction: z

Pathway ::

Direct Ingestion Rate:	0.000E+00	[1/hr]
Fraction released to air:	1.000E+00	
Removable fraction:	2.000E-01	
Time to Remove:	3.650E+02	[day]
Radon Release Fraction:	3.000E-01	

Contamination::

Nuclide	Concentration	Dose Conversion Factors		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-238	4.880E+04	1.212E-04	5.315E-02	7.207E-05
U-235	2.200E+03	1.203E-04	5.541E-02	4.068E-04
U-234	4.880E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	0.000E+00	4.775E-03	5.766E-01	9.054E-05
TH-230	0.000E+00	2.468E-04	1.468E-01	9.189E-07
AC-227	0.000E+00	6.66.7E-03	3.027E+00	9.730E-04
RA-226	0.000E+00	5.991E-04	3.874E-03	4.685E-03
PB-210	0.000E+00	3.275E-03	1.045E-02	4.730E-06

Assessment for Time: 1
Time = 0.000E+00 yr

Source Information

Source: 1

Location::	Room:	1	x:	1.50	y:	1.50	z:	0.0 [m]
Geometry::	Type: Area Pathway			Area:9.00E+00 [m2]				1.0 Direction: z

::

Direct Ingestion Rate: Fraction released	0.000E+00	[1/hr]
to air: Removable fraction:	1.000E+00	
Time to Remove:	2.000E-01	
	3.650E+02	[day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-238	4.880E+04
U-235	2.200E+03
U-234	4.880E+04
PA-231	0.000E+00
TH-230	0.000E+00
AC-227	0.000E+00
RA-226	0.000E+00
PB-210	0.000E+00

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

		Source 1	Total
Receptor	1	6.43E+00	6.43E+00
Total		6.43E+00	6.43E+00

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Pathway Detail of Doses

[mrem)

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.76E-03	4.66E-05	7.68E-07	6.39E+OO	8.23E-12	3.76E-02
Total	2.76E-03	4.66E-05	7.68E-07	6.39E+OO	8.23E-12	3.76E-02

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	2.97E+00	2.97E+00
U-234	4.53E-06	4.53E-06
TH-230	3.40E-11	3.40E-11
RA-226	1.67E-16	1.67E-16
PB-210	0.000E+00	0.000E+00
U-235		
U-235	1.40E-01	1.40E-01
PA-231	1.55E-05	1.55E-05
AC-227	8.41E-07	8.41E-07
U-234		
U-234	3.32E+00	3.32E00
TH-230	3.67E-05	3.67E-05
RA-226	2.74E-10	2.74E-10
PB-210	5.28E-12	5.28E-12

ATTACHMENT G-3

Yellowcake RESRAD-Build Run

Room Size 10m x 10m x 5m

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources Number 1
of Receptors: Total Time 1
Fraction Inside 3.650000E+02 days
2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z	FracTime	Inhalation [m3/day)	Ingestion(Dust) [m2/hr)	[m]
1	1	5.000	5.000	1.000	1.000	1.80E+01	1.00E-04	

Receptor-Source Shielding Relationship ---

Receptor	Source	Density [gI cm3]	Thickness [em]	Material
1	1	2.40E+00	0.000E+00	Concrete

Building Information

Building Air Exchange Rate: 2.00E+00 1/hr

```
Height[m]              Air Exchanges [m3/hr]
Area [m2]
                     ********************************
                     *                                *
                     *                                *
                     *                                <=Q01: 1.00E+03
H1:     5.000        *          Room    1             *       Q10 :     1.00E+03
                     *     LAMBDA: 2.00E+00           *
Area 100.000         *                                *
                     *                                *
                     ********************************
```

Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]

Source Information

Source: 1
Location:: Room: 1 x: 5.00 y: 5.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.00E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00 Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Radon Release Fraction: 3.000E-01

Contamination::

Nuclide	Concentration [pCi/m2]	Dose Conversion Factors: Ingestion [mrem/pCi]	Inhalation [mrem/pCi)	Submersion (mrem/yr/ (pCi/m3)]
U-238	2.200E+04	2.690E-04	1.180E-01	1.600E-04
U-235	9.910E+02	2.670E-04	1.230E-01	9.030E-04
U-234	2.200E+04	2.830E-04	1.320E-01	8.930E-07
PA-231	0.000E+00	1.060E-02	1.280E+00	2.010E-04
TH-230	0.000E+00	5.480E-04	3.260E-01	2.040E-06
AC-227	0.000E+00	1.480E-02	6.720E+00	2.160E-03
RA-226	0.000E+00	1.330E-03	8.600E-03	1.040E-02
PB-210	0.000E+00	7.270E-03	2.320E-02	1.050E-05

Assessment for Time: 1
Time =0.000E+00yr

Source Information

Source: 1
Location:: Room: 1 x: 5.00 y: 5.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.00E+02 [m2] Direction: z
Pathway ::

Direct Ingestion Rate:	0.000E+00	[1/hr]
Fraction released to air: Removable	1.000E+00	
fraction:	2.000E-01	
Time to Remove:	3.650E+02	[day]

Contamination::

Nuclide	Concentration [pCi/m2]
U-238	2.200E+04
U-235	9.910E+02
U-234	2.200E+04
PA-231	0.000E+00
TH-230	0.000E+00
AC-227	0.000E+00
RA-226	0.000E+00
PB-210	0.000E+00

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

		Source 1	Total
Receptor	1	1.93E+01	1.93E+01
Total		1.93E+01	1.93E+01

** RESRAD-BUILD Program Output, Version 3.1 08/07/02 16:06 Page: 7 **
Title : RESRAD-BUILD Ye1lowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	6.98E-03	3.53E-04	2.30E-06	1.92E+Ol	1.48E-11	1.13E-01
Total	6.98E-03	3.53E-04	2.30E-06	1.92E+01	1.48E11	1.13E-01

Title : RESRAD-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	8.91E+00	8.91E+00
U-234	1.36E-05	1.36E-05
TH-230	1.02E-10	1.02E-10
RA-226	4.82E-16	4.82E-16
PB-210	0.000E+00	0.000E+00
U-235		
U-235	4.20E-01	4.20E-01
PA-231	4.66E-05	4.66E-05
AC-227	2.51E-06	2.51E-06
U-234		
U-234	9.96E+00	9.96E+00
TH-230	1.10E-04	1.10E-04
RA-226	7.90E-10	7.90E-10
PB-210	1.58E-11	1.58E-ll

ATTACHMENT G-4

Yellowcake RESRAD-Build Run

Room Size 1OOm x 1OOm x 15m

RESRAD-BUILD Table of Contents

--- RESRAD-BUILD Input Parameters

Number of Sources	1
Number of Receptors:	1
Total Time	3.650000E+02 days
Fraction Inside	2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	**1**	50.000	50.000	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [em]	Material
1	1	2.40E+00	0.000E+00	Concrete

Building Information

Building Air Exchange Rate: 2.00E+00 1/hr

```
Height(m)            Air Exchanges [m3/hr]
Area [m2]
                     *******************************
                     *                               *
                     *                               *
                     *                               <=Q01: 3.00£+05
Hl:    15.000        *          Room   1             *      Q10 :     3.00E+05
                     *    LAMBDA: 2.00E+00           *
Area********         *                               *
                     *                               *
                     *******************************
```

Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]

Source Information

Source: 1

Location:: Room : 1 x: 50.00 y: 50.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.00E+04 [m2] Direction: z
Pathway ::

Direct Ingestion Rate:	0.000E+00 [1/hr]
Fraction released to air:	1.000E+00
Removable fraction:	2.000E-01
Time to Remove:	3.650E+02 [day]
Radon Release Fraction:	3.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factors		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-238	4.880E+04	1.212E-04	5.315E-02	7.207E-05
U-235	2.200E+03	1.203E-04	5.541E-02	4.068E-04
U-234	4.880E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	0.000E+00	4.775E-03	5.766E-01	9.054E-05
TH-230	0.000E+00	2.468E-04	1.468E-01	9.189E-07
AC-227	0.000E+00	6.667E-03	3.027E+OO	9.730E-04
RA-226	0.000E+00	5.991E-04	3.874E-03	4.685E-03
PB-210	0.000E+00	3.275E-03	1.045E-02	4.730E-06

Assessment for Time: 1
Time = 0.000E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 50.00 y: 50.00 z: 0.00 [m) Direction:
Geometry:: Type: Area Area:1.00E+04 [m2) Pathway :: z

Direct Ingestion Rate:	0.000E+00	[1/hr)
Fraction released to air:	1.000E+00	
Removable fraction:	2.000E-01	
Time to Remove:	3.650E+02	[day)

Contamination::

Nuclide	Concentration [dpm/m2]
U-238	4.880E+04
U-235	2.200E+03
U-234	4.880E+04
PA-231	0.000E+00
TH-230	0.000E+00
AC-227	0.000E+00
RA-226	0.000E+00
PB-210	0.000E+00

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

		Source 1	Total
Receptor	1	6.44E+00	6.44E+00
Total		6.44E+00	6.44E+00

Pathway Detail of Doses

[mrem)

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.61E-02	2.72E-04	7.68E-07	6.39E+00	8.23E-12	3.76E-02
Total	1.61E-02	2.72E-04	7.68E-07	6.39E+OO	8.23E-12	3.76E-02

,,

Title : RESRAO-BUILD Yellowcaket
Input File : C:\Winbld\Shootering-yellowcake.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	2.98E+00	2.98E+00
U-234	4.53E-06	4.53E-06
TH-230	3.40E-11	3.40E-11
RA-226	3.77E-16	3.77E-16
PB-210	0.000E+00	0.000E+00
U-235	1.43E-0l	1.43E-01
PA-231	1.56E-05	1.56E-05
AC-227	8.42E-07	8.42E-07
U-234		
U-234	3.32E+00	3.32E+00
TH-230	3.67E-05	3.67E-05
RA-226	6.17E-10	6.17E-10
PB-210	5.28E-12	5.28E-12

ATTACHMENT G-5

Uranium Ore RESRAD-Build Run

Room Size 3m x 3m x 3m

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources Number of Receptors: Total Time Fraction Inside

Number of Sources	1
Number of Receptors:	1
Total Time	3.650000E+02 days
Fraction Inside	2.280000E-01

Receptor Information

Receptor	Room	x [m)	y [m]	z [m)	FracTime	Inhalation [m3/day)	Ingestion(Dust) [m2/hr)
1	1	1.500	1.500	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3)	Thickness [em)	Material
1	1	2.40E+00	0.000E+00	Concrete

Building Information

Building Air Exchange Rate: 2.00E+00 1/hr

```
 Height[m]               Air Exchanges  [m3/hr]
 Area [m2]
                      ******************************
                      *                             *
                      *                             *
                      *                             <=Q01:   5.40E+01
 Hl:      3.000       *          Room   1           *     Q10 :   5.40E+01
                      *    LAMBDA: 2.00E+00         *
 Area     9.000       *                             *
                      *                             *
                      ******************************
```

Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]

Source Information

Source: 1

Location:: Room : 1 x: 1.50 y: 1.50 z: 0.00 [m]
Geometry:: Type: Area Area:9.00E+00 [m2] Direction: z
Pathway ::

Direct Ingestion Rate:	0.000E+00 [1/hr]
Fraction released to air:	1.000E+00
Removable fraction:	2.000E-01
Time to Remove:	3.650E+02 [day]
Radon Release Fraction:	3.000E-01

Contamination::

Nuclide	Concentration [dpm/m2]	Dose Conversion Factors: Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/(dpm/m3)]
(]-238	1.400E+04	1.212E-04	5.315E-02	7.207E-05
U-235	6.300E+02	1.203E-04	5.541E-02	4.068E-04
U-234	1.400E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	6.300E+02	4.775E-03	5.766E-01	9.054E-05
TH-230	1.400E+04	2.468E-04	1.468E-01	9.189E-07
AC-227	6.300E+02	6.667E-03	3.027E+00	9.730E-04
RA-226	1.400E+04	5.991E-04	3.874E-03	4.685E-03
PB-210	9.800E+03	3.275E-03	1.045E-02	4.730E-06

Assessment for Time: 1 =
Time =O.OOE+OO yr

Source Information

Source: 1

Location:: Room : 1 x: 1.50 y: 1.50 z: 0.00 [m]
Geometry:: Type: Area Area:9.00E+00 [m2] Direction: z
Pathway ::

Direct Ingestion Rate:	0.000E+00	[1/hr)
Fraction released to air:	1.000E+00	
Removable fraction:	2.000E-01	
Time to Remove:	3.650E+02	[day]

Contamination::

Nuclide	Concentration [dpm/m2]
0-238	1. 400E+04
0-235	6.300E+02
0-234	1.400E+04
PA-231	6.300E+02
TH-230	1.400E+04
AC-227	6.300E+02
RA-226	1. 400E+04
PB-210	9.800E+03

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem)

		Source 1	Total
Receptor	1	3.53E+01	3.53E+01
Total		3.53E+01	3.53E+01

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.34E-02	2.81E-03	5.84E-05	3.44E+01	8.62E-03	8.23E-01
Total	3.34E-02	2.81E-03	5.84E-05	3.44E+01	8.62E-03	8.23E-01

** RESRAD-BUILD Program Output, Version 3.1 08/08/02 09:14 Page: 52
Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem)

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	4.25E+00	4.25E+00
U-234	6.48E-06	6.48E-06
TH-230	4.70E-11	4.70E-11
RA-226	1.76E-16	1.76E-16
PB-210	0.000E+00	0.000E+00
U-235		
U-235	1.99E-01	1.99E-01
PA-231	2.14E-05	2.14E-05
AC-227	1.13E-06	1.13E-06
U-234		
U-234	4.75E+OO	4.75E+OO
TH-230	5.07E-05	5.07E-05
RA-226	2.93E-10	2.93E-10
PB-210	7.03E-12	7.03E-12
PA-231		
PA-231	2.llE+OO	2.llE+OO
AC-227	1.63E-01	1.63E-01
TH-230		
TH-230	1.17E+01	1.17E+01
RA-226	9.96E-05	9.96E-05
PB-210	3.16E-06	3.16E-06
AC-227		
AC-227	1.06E+01	1.06E+01
RA-226		
RA-226	4.78E-01	4.78E-01
PB-210	2.23E-02	2.23E-02
PB-210		
PB-210	1.04E+00	1.04E+00

ATTACHMENT G-6

Uranium Ore RESRAD-Build Run

Room Size 3m x 3m x 15m

RESRAD-BUILD Table of Contents

--- RESRAD-BUILD Input Parameters

Number of Sources	1
Number of Receptors:	1
Total Time	3.650000E+02 days
Fraction Inside	2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	1.500	1.500	1.000	1.000	1.80E+01	1.00E-04

=== Receptor-Source Shielding Relationship ---

Receptor	Source	Density [g/cm3]	Thickness [em]	Material
1	1	2.40E+00	0.000E+00	Concrete

Building Information

Building Air Exchange Rate: 2.00E+00 1/hr

```
Height[m]            Air Exchanges [m3/hr]
Area [m2]
                 ******************************
                 *                                  *
                 *                                  *
                 *                                  <=Q01: 2.70E+02
 H1:  15.000     *         Room  1                  *     Q10 : 2.70E+02
                 *   LAMBDA: 2.00E+00               *
Area   9.000     *                                  *
                 *                                  *
                 ******************************
```

Deposition velocity: 1.00E-02 [m/s]

Resuspension Rate: 5.00E-07 (1/s)

Source Information

Source: 1

Location:: Room: 1 x: 1.50 y: 1.50 z: 0.00 [m]
Geometry:: Type: Area Area:9.00E+00 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E+00
Removable fraction: 2.000E-01
Time to Remove: 3.650E+02 [day]

Radon Release Fraction: 3.000E-01

Contamination::

Nuclide	Concentration [dpm/m2]	Dose Conversion Factors: Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/(dpm/m3)]
U-238	1.400E+04	1.212E-04	5.315E-02	7.207E-05
U-235	6.300E+02	1.203E-04	5.541E-02	4.068E-04
U-234	1.400E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	6.300E+02	4.775E-03	5.766E-Ol	9.054E-05
TH-230	1.400E+04	2.468E-04	1.468E-01	9.189E-07
AC-227	6.300E+02	6.667E-03	3.027E+OO	9.730E-04
RA-226	1.400E+04	5.991E-04	3.874E-03	4.685E-03
PB-210	9.800E+03	3.275E-03	1.045E-02	4.730E-06

Assessment for Time: 1
Time =0.000E+00yr

Source Information

Source: 1
Location:: Room : 1 x: 1.50 y: 1.50 z: 0. 00 [m]
Geometry:: Type: Area Area:9.00E+00 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: Fraction released 0.000E+00 [1/hr)
to air: Removable fraction: 1.000E+00
Time to Remove: 2.000E01
3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-238	1.400E+04
. U-235	6.300E+02
U-234	1.400E+04
PA-231	6.300E+02
TH-230	1.400E+04
AC-227	6.300E+02
RA-226	1.400E+04
PB-210	9.800E+03

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

		Source 1	Total
Receptor	1	7.11E+00	7.11E+00
Total		7.11E+00	7.11E+00

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.34E-02	5.62E-04	1.17E-05	6.91E+00	3.85E-03	1.66E-01
Total	3.34E-02	5.62E-04	1.17E-05	6.91E+00	3.85E-03	1.66E-01

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	8.50E-01	8.50E-01
U-234	1.30E-06	1.30E-06
TH-230	9.39E-12	9.39E-12
RA-226	4.56E-17	4.56E-17
PB-210	0.00E+00	0.00E+00
U-235		
U-235	4.00E-02	4.00E-02
PA-231	4.29E-06	4.29E-06
AC-227	2.28E-07	2.28E-07
U-234		
U-234	9.49E-01	9.49E-01
TH-230	1.01E-05	1.01E-05
RA-226	7.56E-ll	7.56E-ll
PB-210	1.42E-12	1.42E-12
PA-231		
PA-231	4.21E-01	4.21E-01
AC-227	3.29E-02	3.29E-02
TH-230		
TH-230	2.34E+00	2.34E+00
RA-226	2.57E-05	2.57E-05
PB-210	6.38E-07	6.38E-07
AC-227		
AC-227	2.14E+00	2.14E+00
RA-226		
RA-226	1.23E-01	1.23E-01
PB-210	4.50E-03	4.50E-03
PB-210		
PB-210	2.09E-01	2.09E-01

ATTACHMENT G-7

Uranium Ore RESRAD-Build Run

Room Size 10m x 1Om x 5m

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources	1
Number of Receptors:	1
Total Time	3.650000E+02 days
Fraction Inside	2.280000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTirne	Inhalation [m3/day]	Ingestion(Dust) [m2/hr)
1	1	5.000	5.000	1.000	1.000	1.80E+01	l.OOE-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3)	Thickness [cm]	Material
1	1	2.40E+00	0.000E+00	Concrete

Building Information

Building Air Exchange Rate: 2.00E+00 1/hr

```
Height[m]           Air Exchanges  [rn3/hr]
Area [m2]
                    *******************************
                    *                                   *
                    *                                   *
                    *                                 <=Q01:   1.00E+03
Hl:      5.000      *            Room    1              *        Q10 :     1.00E+03
                    *     LAMBDA: 2.00E+00              *
Area 100.000        *                                   *
                    *                                   *
                    *******************************
```

Deposition velocity: 1.00E-02 [m/s]

Resuspension Rate: S.OOE-07 [1/s]

Source Information

Source: 1

Location:: Room : 1 x: 5.00 y: 5.00 z: 0.00 [m]

Geometry:: Type: Area Area:1.00E+02 [m2] Direction: z

Pathway ::

Direct Ingestion Rate: 0.000E+00 [1/hr]

Fraction released to air: 1.000E+00

Removable fraction: 2.000E-01

Time to Remove: 3.650E+02 [day]

Radon Release Fraction: 3.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factors		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/(dpm/m3)]
U-238	1.400E+04	1.212E-04	5.315E-02	7.207E-05
U-235	6.300E+02	1.203E-04	5.541E-02	4.068E-04
U-234	1.400E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	6.300E+02	4.775E-03	5.766E-01	9.054E-05
TH-230	1.400E+04	2.468E-04	1.468E-01	9.189E-07
AC-227	6.300E+02	6.667E-03	3.027E+00	9.730E-04
RA-226	1.400E+04	5.991E-04	3.874E-03	4.685E-03
PB-210	9.800E+03	3.275E-03	1.045E-02	4.730E-06

Assessment for Time: 1
Time = 0.000E+00yr

Source Information

Source: 1
Location:: Room: 1 x: 5.00 y: 5.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.00E+02 [m2] Direction: z
Pathway ::

Direct Ingestion Rate:	0.000E+00	[1/hr]
Fraction released to air:	1.000E+00	
Removable fraction:	2.000E-01	
Time to Remove:	3.650E+02	[day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-238	1.400E+04
U-235	6.300E+02
U-234	1. 400E+04
PA-231	6.300E+02
TH-230	1.400E+04
AC-227	6.300E+02
RA-226	1.400E+04
PB-210	9.800E+03

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

		Source 1	Total
Receptor	1	2.13E+01	2.13E+01
Total		2.13E+01	2.13E+01

** RESRAD-BUILD Program Output, Version 3.1 08/07/02 15:35 Page: 69
Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Pathwy Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	8.61E-02	4.34E-03	3.50E-05	2.07E+Ol	6.92E-03	4.95E-01
Total	8.61E-02	4.34E-03	3.50E-05	2.07E+Ol	6.92E-03	4.95E-01

\

Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	2.55E+00	2.55E+00
U-234	3.89E-06	3.89E-06
TH-230	2.82E-11	2.82E-11
RA-226	1.31E-16	1.31E-16
PB-210	0.000E+00	0.000E+00
U-235		
U-235	1.20E-01	1.20E-01
PA-231	1.29E-05	1.29E-05
AC-227	6.81E-07	6.81E-07
U-234		
U-234	2.85E+00	2.85E+00
TH-230	3.04E-05	3.04E-05
RA-226	2.17E-10	2.17E-10
PB-210	4.24E-12	4.24E-12
PA-231		
PA-231	1.26E+00	1.26E+00
AC-227	9.82E-02	9.82E-02
TH-230		
TH-230	7.03E+00	7.03E+00
RA-226	7.39E-05	7.39E-05
PB-210	1.90E-06	1.90E-06
AC-227		
AC-227	6.38E+00	6.38E+00
RA-226		
RA-226	3.54E-01	3.54E-01
PB-210	1.34E-02	1.34E-02
PB-210		
PB-210	6.25E-01	6.25E-01

ATTACHMENTG-8

Uranium Ore RESRAD-Build Run

Room Size lOOm x lOOm x 15m

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters ---

Number of Sources Number of Receptors: Total Time Fraction Inside

Number of Sources	1
Number of Receptors:	1
Total Time	3.650000E+02 days
Fraction Inside	2.280000E-01

Receptor Information

Receptor	Room	x [rn]	y [rn]	z [rn]	FracTirne	Inhalation [rn3/day]	Ingestion(Dust) [rn2/hr]
1	1	50.000	50.000	1.000	1.000	1.80E+01	l.OOE-04

Receptor-Source Shielding Relationship ===

Receptor	Source	Density [g/crn3]	Thickness [ern]	Material
1	1	2.40E+00	0.000E+00	Concrete

Building Information

Building Air Exchange Rate: 2.00E+00 1/hr

```
 Height[m]              Air Exchanges [m3/hr]
 Area [m2]
                      *******************************
                      *                                   *
                      *                                   *
                      *                                   <=QOl:    3.00E+05
 Hl:     15.000       *              Room   1             *          QlO       3.00E+05
                      *     LAMBDA: 2.00E+00              *
Area********          *                                   *
                      *                                   *
                      *******************************
```

Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]

Source Information

Source: 1

Location:: Room : 1 x: 50.00 y: 50.00 z: 0.0 [m]

Geometry:: Type: Area Area:1.00E+04 [m2] Pathway :: Direction: z

Direct Ingestion Rate:	0.000E+00	[1/hr]
Fraction released to air:	1.000E+00	
Removable fraction:	2.000E-01	
Time to Remove:	3.650E+02	[day]
Radon Release Fraction:	3.000E-01	

Contamination::

Nuclide	Concentration	Dose Conversion 'Factors		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)J
U-238	1.400E+04	1.212E-04	5.315E-02	7.207E-05
U-235	6.300E+02	1.203E-04	5.541E-02	4.068E-04
U-234	1.400E+04	1.275E-04	5.946E-02	4.023E-07
PA-231	6.300E+02	4.775E-03	5.766E-01	9.054E-05
TH-230	1.400E+04	2.468E-04	1.468E-01	9.189E-07
AC-227	6.300E+02	6.667E-03	3.027E+OO	9.730E-04
RA-226	1.400E+04	5.991E-04	3.874E-03	4.685E-03
PB-210	9.800E+03	3.275E-03	1.045E-02	4.730E-06

\

Assessment for Time: 1
Time = 0.000E+00 yr

Source Information

Source: 1

Location::	Room : 1	x: 50.00	y: 50.00	z: 0.0	[m]
Geometry::	Type: Area		Area:1.00E+04 [m2)		Direction: z

Pathway ::

Direct Ingestion Rate:	0.000E+00	[1/hr)
Fraction released to air:	1.000E+00	
Removable fraction:	2.000E-0-1	
Time to Remove:	3.650E+02	[day)

Contamination::

Nuclide	Concentration [dpm/m2)
U-238	1.400E+04
U-235	6.300E+02
U-234	1.400E+04
PA-231	6.300E+02
TH-230	1.400E+04
AC-227	6.300E+02
RA-226	1.400E+04
PB-210	9.800E+03

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem)

		Source 1	Total
Receptor	1	7.28E+00	7.28E+00
Total		7.28E+00	7.28E+O00

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.97E-01	3.32E-03	1.17E-05	6.91E+00	3.85E-03	1.66E-01
Total	1.97E-01	3.32E-03	1.17E-05	6.91E+00	3.85E-03	1.66E-01

** RESRAD-BUILD Program Output, Version 3.1 08/13/02 12:35 Page: 79
Title : Shootering-U Ore
Input File : C:\Winbld\Shootering-ore.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	8.53E-01	8.53E-01
U-234	1.30E-06	1.30E-06
TH-230	9.39E-12	9.39E-12
RA-226	1.05E-16	1.05E-16
PB-210	0.000E+00	0.000E+00
U-235		
U-235	4.08E-02	4.08E-02
PA-231	4.29E-06	4.29E-06
AC-227	2.28E-07	2.28E-07
U-234		
U-234	9.50E-01	9.50E-01
TH-230	1.01E-05	l.OlE-05
RA-226	1.74E-10	1.74E-10
PB-210	1.42E-12	1.42E-12
PA-231		
PA-231	4.21E-01	4.21E-01
AC-227	3.29E-02	3.29E-02
TH-230		
TH-230	2.34E+00	2.34E+00
RA-226	5.91E-05	5.91E-05
PB-210	6.39E-07	6.39E-07
AC-227		
AC-227	2.14E+00	2.14E+00
RA-226		
RA-226	2.84E-01	2.84E-01
PB-210	4.50E-03	4.50E-03
PB-210		
PB-210	2.10E-01	2.10E-01

APPENDIX H

BUILDING CONTAMINATION SURVEY AND SAMPLING PLAN

APPENDIX H

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TABLES

ATTACHMENTS

Appendix H
Building Contamination Survey and Sampling Plan

H.0 Introduction

The procedures for conducting gross alpha surface contamination surveys follow guidance prepared by the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance (NUREG-1575). The instrumentation performance calculations assume that all contamination is yellowcake. This is a conservative assumption since the average energy of the alpha particles from yellowcake is less than for uranium ore. This will be conservative since it will underestimate the efficiency of the detectors when ore is present, thus increasing the estimated MDA, reducing the allowable scanning speed, and overestimating the uranium ore contamination level.

At this time, it is believed that once the process equipment has been removed from the buildings and the structure has been washed, the walls and ceilings will be uncontaminated. At this time, Uranium One Americas is not permitted to discharge water to the tailings area and thus cannot wash the surfaces. The data in Section 3.3 indicate relatively low levels of contamination in the mill building (excluding the yellowcake processing area) which is consistent with a facility that has had limited use as a uranium mill.

The gross alpha contamination limit for the floors of structures was calculated to be 700 dpm/100 cm^2. The walls and ceilings of the rooms were assumed to be uncontaminated. If significant contamination is found on the walls and ceiling, the contamination limits may have to be adjusted. The limit was found to be independent of the room. Since the exposure pathway was almost exclusively due to inhalation (See Appendix G), there is no maximum limit and thus no area factor.

It will be shown that as a part of ALARA, the scanning technique will have a high probability of identifying all areas of contamination at, or above the DGCL. These areas will be further decontaminated resulting in an average surface contamination for each survey area that is significantly less than the DGCL. In MARSSIM terminology, the 700 dpm/100 cm^2 gross alpha limit is the derived concentration guideline level (DCGL).

H.l Area Classification and Survey Unit Sizes

For most of the structures within the radiological restricted area, the floors and walls up to a height of 3 feet are made of concrete and classified as Class 1 or 2. The walls above three feet high and ceiling are metal and normally classified as Class 2 or 3, depending on site knowledge. Table H-1 provides a complete listing of the affected structures and the classification.

Table H-1 Survey Classification of Areas

Area/Location	Classification	Source
Office floor	Class 3	
Guard station floor	Class 3	
Scales	Class 2	Ore
Scale house floor	Class 2	Ore
Walls/ceiling	Class 3	
Sample preparation building floor/walls up 3'	Class 2	Ore
Ore hopper/grizzly	Class 2	Ore
Conveyor feeder	Class 2	Ore
Conveyor belt line only belt	Class 1	Ore
Structure	Class 2	Ore
Temporary generators area	Class 3	
Pump/fire bouse floor	Class 3	
Main fresh water tanks	Class 3	
Acid tank	Class 3	
Diesel fuel tank	Class 3	
Power house control room floor	Class 3	
Power house gensets floor	Class 3	
Air compressors floor	Class 3	
Dry floor/ walls up 3'	Class 2	Ore/Yellowcake
Switch ear room floor	Class 3	
SAG mill floor	Class 1	Ore/Yellowcake
Walls up 3'	Class 1	Ore/Yellowcake
Wall/ceiling	Class 2	Ore/Yellowcake Process
Leach floor	Class 1	Yellowcake
Walls up3'	Class 1	Yellowcake
Wall/ceiling	Class 2	Yellowcake
Control room floor	Class 1	Ore/Yellowcake
Walls up 3’	Class 1	Ore/Yellowcake
Wall/ceiling	Class 2	Ore/Yellowcake
Water tank outside near leach walls up 3'	Class 2	Yellowcake
Mill offices floors	Class 2	Ore/Yellowcake
Wall/ceiling	Class 2	Ore/Yellowcake
Reagent room floor	Class 2	Yellowcake
Wall/ceiling	Class 2	Yellowcake Process
Solvent extraction floor	Class 1	Mill process
Wall up 3’	Class 1	Mill process
Wall/ceiling	Class 2	Mill process
Yellowcake precip/drying area floor	Class 1	Yellowcake
Walls up 10’	Class 1	Yellowcake
Lab floor	Class 2	Ore/Yellowcake
Walls up 3’	Class 2	Ore/Yellowcake
Wall/ceilings	Class 3	Ore/Yellowcake
Maintenance shop floor	Class 2	Ore/Yellowcake
Wall/ceilings	Class 3	Ore/Yellowcake
Warehouse floor	Class 2	Ore/Yellowcake
Wall/ceiling	Class 3	Ore/Yellowcake

Definitions:

Ore -Natural uranium ore mined from the ground with no enrichment and in natural equilibrium. For Ibis table, it includes uranium ore that has been reduced in size and placed into a solution so as to leach uranium from the solids.

Yellowcake - Uranium oxide or yellow cake is a liquid or solid in which the uranium bas been concentrated and decay products have been removed or reduced in concentration.

Class 1 - Direct contact with lle(2) material, possibly above DCGL.

Class 2 - Indirect contact defined as possible transport of 1 I e(2) material to item in question and possibly some low level of activity below DCGL.

Class 3- No contact with lle(2) material and activity below DCGL or no activity.

The size of the Class 1 area is limited to the area of the floor plus lower wall of each room. MARSSIM suggests that Class 1 areas for structures be limited to 100 m^2 unless justified. For many of the buildings, the area associated with a classification will be small and thus survey units will be on the order of 100 m^2. This includes the Office, Guard Station, Scale house, Sample Preparation Building, and Control Room. The Mill Building, however, has rooms up to 10,000 m^2 in size. Future use of this building is expected to be by an industry desiring high ceilings (15 m) and large room sizes. Therefore it is unlikely that partitions will be placed in the rooms and thus the TEDE to occupants will be a function of average contamination on the floor and the ceiling height (See Appendix G). It will be demonstrated that the proposed scanning method will be able to identify very small areas contaminated at or above the DCGL. For Class 1 areas, a 100 percent scan will be performed and areas approaching the DCGL will be further decontaminated. This will assure that contamination within the entire Class 1 area is uniformly low. We propose that the survey unit size within the mill building be limited to 2,500 m^2 . We anticipate that this will still result in more than 100 sampling points for the Class 1 areas in each of the large rooms within the mill building. For the Class 2 areas, approximately 10 percent of the area will be scanned using a biased sampling approach. If contamination above the DCGL is found, the area will be reclassified as Class 1. A sampling strategy similar to the Class 1 strategy will be used for the Class 2 areas in the buildings. This will result in additional samples taken in each room. Therefore, the total number of sampling points will be excess of one hundred for each of the large rooms.

H.2 Equipment

The gross alpha scanning surveys will be conducted on floor surfaces using a Ludlum Model 239-lF Floor Monitor (or equivalent). The floor monitor has a Ludlum Model 43-37 gas proportional detector with an active area of 582 cm^2 . The detector window active area is 43.8-cm wide and 13.3-cm long. The alpha background for this detector is typically less than 5 cpm. For difficult to access areas, smaller gas proportional counters or alpha ZnS detectors will be used. The scanning speeds will be determined by detector size, the measured background count rate, and the detector efficiency. MARSSIM methods for calculating scanning speeds have been used.

Static measurements (measurements at a single point) will also be made using the floor monitor or other gas proportional or ZnS detectors. The counting time will be adjusted to assure a minimum detectable activity (MDA) of less than 25 percent of the DCGL of 700 dpm/cm^2 .

Detector efficiency measurements were made for the Model 43-90 and Model 43-37 detectors using an N1ST-traceable depleted uranium source. While it is true that the efficiency will be slightly higher for a natural uranium source due to the higher average alpha energy, the use of the efficiency from depleted uranium is conservative and thus should overestimate the level of contamination when surveying ore areas. The Model 43-90 had an alpha efficiency of 13 percent when the detector was in contact with the surface while only 5.5 percent when the detector was placed at 11 mm from the surface. The Model 43-37 had an alpha efficiency of 9 percent at a height of 11 mm from the surface. The Models 43-20 and 43-68 should have similar efficiencies as the Model 43-37. The background count rates for the detectors were measured but may have to be adjusted for specific site conditions. Estimates of the gross-alpha MDA for a one-minute static count are provided in Table H-2 using Equation 6-7 from MARSSIM.

Table H-2. MDA for Measurement of Uranium Surface Contamination Using a One-Minute Count

Manufacturer	Model	Background (cpm)	Active Area (cm^2)	Alpha Efficiency	MDA (dpm/100 cm^2)
Ludlum	43-37	4	582	0.09	26
Ludlum	43-20	2	181	0.09	59
Ludlum	43-68	1	126	0.09	67
Ludlum	43-90	1	126	0.055	111

The MDAs will be evaluated at the site and may be changed slightly when actual background count rates for the facility are used. The counting times will be changed to obtain an MDC of less than 25 percent of the DCGL (175 dpm/100 cm^2) for gross alpha measurements, based on the background count rate in the facility.

The critical level, L_c, is defined as the net response level, in counts, at which the detector output can be considered above background. For this project, a 5 percent error rate has been assumed for both the Type 1 and Type 2 errors where Equation 6-6 is used to calculate both the critical levels and detection limit. For static one-minute counts, the floor monitor has an $L_c = 5$ counts, the Ludlum 43-20 has an $L_c = 3$ counts, and the Ludlum 43-90 and Ludlum 43-68 have an $L_c = 2$ counts. Therefore, any area where the net counts (after subtracting background counts) exceed these levels is considered above background. Again, this may change as the background changes at the facility.

H.3 Scanning Surveys and Decontamination

H.3.1 Class 1 Areas

A scanning survey will be conducted on all surfaces using a floor monitor. The detector may be removed from the floor monitor and manually placed on wall surfaces. With a low background count rate, the technician will consider stopping upon hearing a count to determine whether the count was from contamination or a spurious background count. The maximum scanning speed for an instrument was calculated using Equation 6-12 in MARSSIM and the detector parameters noted above. The result shows that in order to have a probability of at least 95 percent of observing at least one count while passing over an area the size of the detector contaminated at 700 dpm/100 cm^2, the scanning speed has to be 27 cm/sec or less. This is a very fast scanning speed and shows that the instrumentation is adequate for the task. Application of equation 6-13 shows that if one stops for a minimum of 0.4 seconds after hearing a count, there is a 90 percent probability that an additional count will be observed within the 0.4 seconds, providing the area is contaminated at the DCGL level of 700 dpm/100 cm^2 level or higher. These and other calculations using the formulae referenced above are shown in Attachment H-1.

A more practical approach is for the technician to stop after hearing 2 counts in 1 second. Applying equation 6-14 shows that there is a 98.5 percent probability that 2 or more counts will be registered in **1** second while traversing an area contaminated at the limit of 700 dpm/100 cm^2. If the technician stops when he/she hears 2 counts within a 1 second period and investigates further, the calculations indicate that areas greater than 0.18 m^2 contaminated at or above the limit will be investigated. In order to arrive at that number, since the detector is 43.8-cm wide and 13.3-cm long, the area covered in the 1 second at the rate of 27 cm/sec will be equal to:

$$\text{Area covered} = (w * l) + (w * v * t)$$

Where: detector width= w = 43.8 cm, detector length= l = 13.3 cm, scanning speed = v = 27 cm/sec, and time = t = 1 seconds.

$$\text{Area covered} = (43.8 * 13.3) + (43.8 * 27 * 1) = 1765 \text{ cm}^2\text{, or approximately } 0.18 \text{ m}^2.$$

Areas identified as exceeding the 700 dpm/100 cm^2 action level will be delineated and investigated further by static-point measurements. Further attempts at decontamination will be made to assure compliance with the ALARA goal of reducing the levels as low as reasonably achievable.

The dose assessment (see Appendix G) was based on a floor area of 100 m^2 with uniform contamination. The dose calculations show that the principal dose pathway is via inhalation of resuspended contaminated dust. The direct gamma exposure pathway was not significant and therefore no "hot spot" criteria are proposed for these buildings. However, the proposed scanning method should specifically identify all but a very insignificant percentage of the 0.18-m^2 areas having contamination above the criterion. Larger areas contaminated at the DCGL will, with almost certainty, be detected and decontaminated to ALARA levels. The ALARA efforts at reducing the contamination levels in these special areas should result in an average contamination level that is considerably less than the DCGL.

H.3.2 Class 2 Areas

A minimum of twenty-five percent of the Class 2 area will be scanned using the Ludlum Model 43-37 detector (or equivalent) taken from the floor monitor at a speed of not more than 27 cm/s. This includes 100 percent of floor areas. The performance criteria and method of scanning will be the same as calculated for the Class 1 area presented above.

Smaller detectors, coupled to a rate meter/scaler may be used in small or difficult to access areas. Applying Equations 6-12 and 6-13 to the Model 43-90 detector shows that in order to have a 95 percent probability of detecting at least one count while passing over an area the size of the detector contaminated at the 700 dpm/100 cm^2 level, a maximum scanning speed of 2 cm/sec should be used. If one stops for 3 seconds, there is a 90 percent probability of at least one other count if the contamination limit of 700 dpm/100 cm^2 is exceeded (from Equation 6-13).

Another option for scanning walls or hard to access areas is to use a smaller detector, such as the Ludlum 43-20. This gas proportional detector is approximately 10.2-cm wide and 17.8-cm long with an active area of 181 cm^2. It is expected to have the same efficiency (9 percent) for uranium alpha particles as the Ludlum 43-37 detector on the floor monitor. The background would be expected to be 2 cpm. Applying Equations 6-12, 6-13, and 6-14 from MARSSIM to the Model 43-20 detector shows that in order to have a 95 percent probability of detecting at least one count while passing over an area the size of the detector contaminated at the 700 dpm/100 cm^2 level, a maximum scanning speed of 6 cm/sec should be used. If one stops for 1.2 seconds, there is a 90 percent probability of at least one other count. The calculations show that two or more counts should be recorded within a time period of 2.5 seconds more than 95 percent of the time while scanning an area at the DCGL of 700 dpm/100^2. At a scanning speed of 6 cm/sec, the corresponding area traversed, using the same equation used in Section H.3.1, in 2.5 seconds is (10.2 * 17.8) + (17.8 * 2.5 * 6) = 448 cm^2. This would imply that smaller spots contaminated at the DCGL would not be identified if the 2 counts/2.5 second criteria were applied while scanning. The 2-count criterion using this detector is considered acceptable since missing isolated "hot spots" will not result in a significant TEDE to future occupants.

Should areas of contamination be found in Class 2 areas that exceed 700 dpm/100 cm^2 the area will be reclassified as Class 1 and Class 1 survey and verification procedures will be followed.

H.3.3 Class 3 Areas

The floors of rooms or buildings classified as Class 3 will be scanned using the same scanning technique as for Class 1 and Class 2. Biased static surface-contamination measurements will be made near floor drains, horizontal ledges, and HVAC systems using one of the detectors described in previous sections. Counting times will typically be one minute but adjusted, if necessary, to assure an MDA ofless than 25 percent of the DCGL of 700 dpm/100 cm^2. Biased static-point measurements will be made at a minimum of 30 locations within each building. One or more measurements will be made in all areas where site specific knowledge indicates a potential for contamination. Potential sampling points include horizontal ledges, surfaces, and beams where dust may have collected as well as in and around HVAC and other ducts.

Measurements results from Class 3 areas that exceed 25 percent of the limit of 700 dpm/100 cm^2 will indicate a need to reclassify at least a portion of the Class 3 area as Class 2. A scan of at least 25 percent of this Class 2 area will be done according to Class
2 procedures.

H.4 Final Verification (Status) Survey

The MARSSIM guidance for developing a final status survey is based on the existing data and professional judgment. The method recognizes that small changes may be required as additional data are gathered.

H.4.1 Class 1 Areas

In order to determine that the Class 1 areas meet the DCGL, the areas will be divided into survey units of 2500 m^2 or less, using a grid system appropriate for each structure. The purpose of the Final Verification Survey is to demonstrate that each survey unit meets the cleanup criteria. In this case, the result of the dose modeling effort showed that a surface contamination limit of 700 dpm/100 cm^2, averaged over the entire area, would not result in a TEDE of more than 25 mrem/y to the occupant.

Historical surface contamination data show that the background contamination levels are a very small fraction of the DCGL value of 700 dpm/100 cm^2 and thus the background level may be ignored (assumed to be zero).

The null hypothesis, H_O, is that the survey unit exceeds the release criterion. Therefore it will be necessary to demonstrate that the null hypothesis can be rejected prior to release of the survey unit. A Type 1 decision error (α) would release the unit containing activity that exceeds the limit. A Type 2 decision error (ß) is to incorrectly accept the null hypothesis, resulting in unnecessary work. For this project, we will accept *5* percent for both α and ß decision errors.

The next task is to calculate the relative shift parameter as defined in MARSSIM by the equation:

$$(DCGL-LBGR)/\sigma$$

Where: DCGL is 700 dpm/100 cm^2, the Lower Bound of the Gray Region (LBGR) is to be defined, and σ is the standard deviation of the measurements.

In Section H.3, it was shown that the scanning capability of the proposed instrumentation is very good and that significantly large hot spots will be identified and investigated further. Where practical, these areas will be further cleaned to ALARA levels. Since all Class 1 surfaces will be scanned, this reduces the probability that a significant fraction of the survey unit will exceed the cleanup criterion. In addition, further cleaning will result in reducing the levels and thus result in reducing the standard deviation of the measurements in the final verification survey. It is reasonable to expect a standard deviation of 300dpm/100 cm^2 for the verification data for each Class 1 survey unit. Assuming a LBGR of 350dpm/100 cm^2, the relative shift is 1.2. Substituting into the equation 5-2 of MARSSIM, the number of fixed point measurements in each survey area, N, is calculated to be

$$\mathbf{N} = (Z_{1-\alpha}\ Z_{1-\beta})^2 / 4(\text{Sign P} - 0.5)^2 = 18$$

Where: $Z_{1-\alpha} = Z_{1-\beta} = 1.645$ from Table 5.2 and Sign P = 0.885 from Table 5.4

Using the equations in MARSSIM, the number of data points to demonstrate compliance is calculated to be 18. Increasing this by 20 percent, as recommended, brings the total measurements per survey area to 22.

H.4.2 Class 2 and Class 3 Areas

Class 2 and Class 3 areas are not anticipated to be contaminated and therefore the contaminant distribution should be near background levels. We have assumed that the background levels are insignificant and that the one-sample Sign test applies. It is estimated that the standard deviation of the areas will be approximately 100 dpm/100 cm^2. Assuming a LBER of 350 dpm/100 cm^2 would still result in a relative shift of 3.5, where the Sign P is equal to 1**.** Type 1 errors are not as significant in Class 2 and Class 3 areas since the potential for exposure is much less from the lower walls and ceiling than for the floor (The floors will be scanned). Therefore we have chosen $\alpha = 0.2$. We have limited Type 2 errors to 0.1 since this type of error would necessarily involve further unnecessary remediation or further sampling. Type 2 errors set $\beta = 0.1$.

It is reasonable to expect a standard deviation of 100 dpm/100 cm^2 for these areas. Assuming a LBGR of 350 dpm/100 cm^2, the relative shift is 3.5. Substituting into the equation 5-2 of MARSSIM, the number of fixed point measurements in each survey area, N, is calculated to be

$$N = (Z_{1-\alpha}\ Z_{1-\beta})^2 / 4(\text{Sign P} - 0.5)^2 = 4.5$$

Where: $Z_{1-\alpha}$ = .842 and $Z_{1-\beta}$ = 1.282 from Table 5.2 and Sign P = 0.885 from Table 5.4

Using the equations in MARSSIM, the number of data points to demonstrate compliance is calculated to be 5. Increasing this by 20 percent, as recommended, brings the total measurements per survey area to 6.

H.5 Measurement and Grid Construction

A grid will be established across all survey units according to guidance in MARSSIM. Twenty-two static point measurements will be made in Class 1 survey units and 6 measurements will be made in Class 2 and Class 3 survey units. Data normally will be collected for one minute using standard operating procedures. A drawing of the grid and sampling points will be prepared and documented.

H.6 Data Evaluation

With the assumption that the background can be ignored, the data are evaluated using the MARSSIM guidance. If all values within a survey unit are below the criterion, the survey unit passes. If individual values exceed the criterion, the Sign Test will be applied to the data and the result used to determine whether the unit passes or fails.

H.7 References

NUREG-1575. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). Published jointly by the U.S. Nuclear Regulatory Commission, U. S. Environmental Protection Agency, U. S. Department of Energy, and the U. S. Department of Defense. August, 2000.

ATTACHMENT H-1

DETECTION PROBABILITIES

Attachment H-1. Detection Probabilities

Ludlum Model 43-37

Probability of Detecting One Count at Scanning Speed v

P_1	G	E	d	v
1.000	4074	0.09	13.3	10
0.983	4074	0.09	13.3	20
0.951	4074	0.09	13.3	27
0.934	4074	0.09	13.3	30
0.870	4074	0.09	13.3	40
0.804	4074	0.09	13.3	50

Probability of Two Counts Detected in Time t

P_2	G	E	t	B
0.985	4074	0.09	1	4
0.975	4074	0.09	0.9	4
0.958	4074	0.09	0.8	4
0.929	4074	0.09	0.7	4
0.884	4074	0.09	0.6	4
0.814	4074	0.09	0.5	4

Parameter

P_1	Probability of observing a single count in time interval t. MARSSIM Eq. 6-12
P_2	Probability of observing two or more counts in time interval t. MARSSIM Eq. 6-14
G	Contamination activity(dpm)
E	Detector efficiency (4π)
d	Width of detector in direction of scan (cm)
v	Scan speed (cm/s)
t	Time (sec)
B	Instrument background counts (cpm)

LudlumModel 43-90

Probability of Detecting One Count at Scanning Speed v

P_1	G	E	d	v
0.998	882	0.055	7.5	1
0.952	882	0.055	7.5	2
0.868	882	0.055	7.5	3
0.780	882	0.055	7.5	4
0.703	882	0.055	7.5	5

Probability of Two Counts Detected in Time t

P_2	G	E	t	B
0.990	882	0.055	8	1
0.979	882	0.055	7	1
0.958	882	0.055	6	1
0.917	882	0.055	5	1
0.841	882	0.055	4	1

Ludlum Model 43-20

Probability of Detecting One Count at Scanning Speed v

P_1	G	E	d	v
0.998	1267	0.09	10.2	3
0.979	1267	0.09	10.2	5
0.960	1267	0.09	10.2	6
0.937	1267	0.09	10.2	7
0.911	1267	0.09	10.2	8

Probability of Two Counts Detected in Time t

P_2	G	E	t	B
0.979	1267	0.09	3	2
0.954	1267	0.09	2.5	2
0.898	1267	0.09	2	2
0.786	1267	0.09	1.5	2

APPENDIX I

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RADIATION SAFETY PROGRAM
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APPENDIX J

INFILTRATION MODELING

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APPENDIX J
Infiltration Modeling

J.0 Introduction

The Leaching Estimation And Chemistry Model (LEACHM) (Wagenet and Hutson, 1987) and the Hydrologic Evaluation of Landfill Performance (HELP) model (Schroeder et. al, 1994) were used to predict the infiltration through the radon/infiltration barrier at the Shootaring Canyon Uranium Processing Facility. The planned cover system for the tailings disposal facility at this site is a rock mulch erosion protection layer overlying a freeze/thaw protection layer which in tum overlies a clay radon/infiltration barrier. The primary concern is the percolation of water through the barrier into the dewatered uranium tailings, and subsequent accumulation for eventual passage through the clay liner beneath the tailings. While it is not possible to completely preclude infiltration through the barrier in the long-term, proper selection of barrier materials and construction techniques can reduce the infiltration to minimal levels.

The climate at the Shootaring Canyon facility is very arid with relatively high temperatures. The surface of the tailings pile will be shaped to eliminate ponding on the surface. A limited precipitation depth and high evaporative demand combine to limit the quantity of water available for infiltration. The layer sequence for the tailings includes a freeze/thaw barrier that will prevent degradation of the underlying clay barrier material.

J.l Model Descriptions

The LEACHM water flow model is based on a numerical solution to the Richards equation. Although the complete LEACHM model contains components for plant growth and a variety of chemistry and transport methodologies, only the water flow portion was considered in predicting infiltration. Richards' equation describes transient soil water flow and is solved by the finite difference technique for a one-dimensional (vertical flow only) case in the LEACHM model. As such, the LEACHM model is computationally intensive, but is considered to be a much better representation of saturated/unsaturated water flow than simplified "water balance" models. Unfortunately, the LEACHM model does not allow usable runoff calculations or lateral drainage for sloping conditions.

The HELP model is a comprehensive water balance type model intended for use on lined or capped systems. This model is attractive for situations where barrier material is overlain by topsoil, but the water flow component discussed in the following paragraph is limiting for the evaporative conditions present on the tailings impoundment. The HELP model incorporates several widely-accepted components for stochastic weather generation, evapotranspiration calculations, runoff calculations, and soil hydraulic parameter estimation. The model is also flexible in terms of layer sequencing for complex barrier configurations.

The basic unsaturated water flow model component for the HELP model is a simplistic Darcy equation. Unsaturated hydraulic conductivity is estimated using a method developed by Rawls et al. (1982). The primary disadvantage to the HELP model is the incorporation of the simplified water flow modeling. The alternative to this simplified model is use of a numerical solution of Richards' equation such as that used in the LEACHM model (Wagenet and Hutson, 1989). However, the simplicity provided by the Darcy flow regime shortens required computation and, in part, allows more comprehensive water balance modeling.

A USDOE publication titled "Infiltration Uncertainty Assessment For UMTRA Project Disposal Cell Covers" cites the advantages and limitations for the HELP model and a numerical model, UNSAT-H. The formulations of the UNSAT-H and LEACHM models are generally similar, and the USDOE comparison supports the use of a numerical model as a primary predictor of infiltration. Although the comparison was arrived at independently, the analyses contained in this document and the USDOE comparison of the two models yield similar conclusions regarding model use.

J.l.l HELP Model Description

The HELP model is intended primarily for cover design and is very attractive for this situation from that standpoint. The simplified Darcian flow regime provides a pseudo-transient flow regime. Coupled with extensive supporting computations, such as runoff and lateral flow abstractions from infiltration, the HELP model represents a very comprehensive modeling system. Unfortunately, the simplified flow regime is severely limiting for the typical radon barrier configuration.

The limiting condition for the use of the HELP model in this application is the fact that it will not allow upward flux of water from a barrier layer. In the context of HELP model rules governing layer sequencing, this can dramatically reduce water removal from the radon/infiltration barrier by evaporation. Water that is not removed by other means must eventually infiltrate through the barrier, and this can result in dramatic overprediction of infiltration rates with the design radon/infiltration barrier. Another potential serious flaw in the HELP model is the method of implementation of the lateral drainage option. The layer sequencing rules result in limiting calculable lateral drainage to a layer directly above a liner or barrier layer. In practice, there is potential for lateral drainage whenever there is a layer transition to less permeable material with some slope to a collection system.

The HELP model does include some innovative techniques for calculating runoff. These components could be very useful for some configurations. HELP also includes stochastic weather generation routines with a database of site specific climate information, a large variety of default soil characteristics, and a thoroughly documented means of calculating soil hydraulic properties. These features make the HELP model useful for comparative purposes with results from the LEACHM model.

J.1.2 LEACHM Model Description

The Richards Equation is a partial differential equation derived from the equation of continuity and the Darcy equation. The Richards equation can be used to describe one-dimensional (vertical) flow of water under saturated/unsaturated conditions. Unfortunately, this equation must be solved by numerical methods for all but very simple conditions. In LEACHM, this equation is solved by the implicit finite difference technique, which is implemented in a FORTRAN program. The LEACHM code limits the modeling to layers of uniform thickness and also uses metric units. The LEACHM code also includes various implementations of the Convection Dispersion Equation (CDE) for transport modeling, but these were not used in this application.

The Richards equation describes vertical water flow or flux with gradients induced by gravity, evaporative demand and evapotranspiration. The water flux can be upward or downward, depending on these gradients. The limited infiltration allowed in the modeling scenarios for this application taxes the limits of accuracy for the numerical solution employed in LEACHM, but this could be said for virtually any numerical transient flow model. Use of very small layer thicknesses can partially compensate for this limitation, but the large gradients present under arid conditions will invariably produce errors.

The LEACHM model allows input of precipitation on a daily or even more frequent basis. Evaporation is input on a weekly basis throughout the year. The model will allow cycling through a single year or several years' worth of data as many times as desired. This allows simulation of an indefinite number of years to reach an equilibrium condition or to monitor a drainage or restoration condition. This feature was used to allow seepage through the tailings impoundment to reach equilibrium. The LEACHM model does not have any provisions for predicting runoff for nonspecific storms or an increase in head due to ponding of water. While the latter condition is not likely to be a problem on the tailings impoundment, the runoff or lateral drainage from the impoundment through the rock protection will undoubtedly be important to the prevention of infiltration. The methods for incorporating runoff and lateral drainage into the LEACHM modeling are discussed in a later section. LEACHM also allows evapotranspiration under a variety of vegetative conditions. This feature was not used in these simulations.

J.2 Model Inputs

The inputs to the model were taken from field-measured values when available, and model defaults when actual data were not available.

The HELP model defaults include a wide variety of soil types and local weather generation coefficients for locations in Utah, and where applicable, the HELP model input data was used in the LEACHM model to allow as direct a comparison as possible.

J.2.1 Cover Material Properties

J.2.1.1 HELP Model

The properties of the rock were estimated. The surface layer of 8 inches of rock was modeled as gravel. The default properties indicated in Table J-1 were used in the simulation. A second HELP simulation used loamy fine sand for the surface rock layer under the assumption that the rock layer may become filled with fines over time.

Table J-1. HELP Model Run Summary

HELP Model Run	Layer	Layer Type	Gradation No.	Thick (inch)	Hyd. Cond. (cm/s)	Lateral Drainage Layer Slope (%)	Lateral Drainage Layer Slope Length (feet)	Qtr.	RH (%)	CN	Wind Speed (mph)	Year	Precip. (inch)	Runoff (inch)	Lateral Drainage (inch)	ET (inch)	Infiltration Through Barrier (inch)
1	1	1	21	8	0.3	3	8OO	1	54	50	9	1974	5.64	0	0	5.618	0.020
	2	1	5	18	0.001			2	25.8			1975	9.33	0	0	8.758	0.092
	3	2	5	6	0.001			3	23.5			1976	4.58	0.003	0	4.949	0.091
	4	3	16	18	1.0E-007			4	47.5			1977	5.45	0	0	4.681	0.078
	5	1	6	60	7.2E-004							1978	9.97	0.009	0	10.277	0.112
											Averages		6.994	0.0024	0	6.8566	0.079
2		1	5	8	0.001	3	8OO	1	54	65	9	1974	5.64	0	0	5.838	0.042
		1	5	18	0.001			2	25.8			1975	9.33	0	0	8.427	0.086
	3	2	5	6	0.001			3	23.5			1976	4.58	0.007	0	5.511	0.070
	4	3	16	18	1.0E-007			4	47.5			1977	5.45	0	0	4.423	0.055
	5	1	6	60	7.2E-004							1978	9.97	0.013	0	10.192	0.097
											Averages		6.994	0.004	0	6.8782	0.070

HELP Soil Gradations

Gradation Number	Material Type	Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conductivity (cm/s)
2	Sand	0.437	0.062	0.024	5.8E-003
5	Loamy Fine Sand	0.457	0.131	0.058	1E-003
6	Sandy Loam	0.453	0.19	0.085	7.2E-004
16	Barrier Soil	0.427	0.418	0.367	1.0E-007
21	Gravel	0.397	0.032	0.013	3.0E-001
28	Compacted Silty Clay	0.452	0.411	0.311	1.2E-006

HELP Layer Types

Layer Number	Layer Type
1	Vertical Percolation
2	Lateral Drainage
3	Soil Liner
4	Geomembrane Liner

A range of gradations was used to model the native soil in the 24 inches of freeze/thaw layer. The properties of these materials are listed in the lower section of Table J-1. Layers 2 and 3 were the freeze/ thaw layer in the HELP simulations, and the separation was made to allow consideration of lateral drainage conditions. The properties of this layer were varied from sand to a sandy loam. The bulk of the material is sand to gravel with approximately 10 to 15% silt and clay, although it is likely that there will be considerable variability in this rocky soil cover.

The clay radon/infiltration barrier was modeled as compacted clay with a saturated hydraulic conductivity of 1.OE-07 cm/sec. The proposed material for the clay barrier has clay and silt fractions of 80% or greater. Layer 4 in Table J-1 was the radon/infiltration barrier in the HELP modeling.

J.2.1.2 LEACHM Model

The properties of the rock were estimated. For the rock mulch; the hydraulic conductivity was estimated as 1 cm/sec, the density was estimated as 1.46 kg/dm^3 the organic carbon content was estimated as 0.1% and the rock was assumed to have no silt and clay fraction. The remainder of the cover profile was developed to be similar to that of HELP simulation #1 in Table J-1.

J.2.2 Tailings Properties

J.2.2.1 HELP Model

The tailings, ore material, or interim cover directly beneath the clay barrier material was assumed to be a moderately permeable sand. The properties of this material are presented in the gradation types in Table J-1. The required layer sequencing in HELP prevents upward movement of water through the barrier, and thus the physical properties of the tailings have little or no effect on volume of infiltrate.

J.2.2.2 LEACHM Model

A moderately permeable sand was assumed to be present below the barrier. The lower boundary was assumed to be freely draining. This may be slightly conservative because it introduces a slightly greater gradient across the infiltration barrier. However, the base of the profile was generally placed far enough below the clay radon/infiltration barrier to minimize boundary effects. The model is not particularly sensitive to the properties of the material underlying the barrier unless the permeability of the underlying material approaches that of the barrier, or the infiltration is so small that numerical accuracy becomes an issue. Once the infiltrate reaches a certain depth in the barrier, it is unlikely that it will move upward to supply evaporative demand. Because the barrier is less permeable than any of the modeled underlying tailings, ore or interim cover materials, the model is not particularly sensitive to the physical properties of these materials.

J.2.3 Precipitation and Weather Conditions

The precipitation values were taken from estimates in the Decommissioning and Reclamation Plan. The estimate for annual precipitation was 7 inches. Climates of the States (1978), lists the annual precipitation for Hanksville, Utah as 5.21 inches. This is the nearest location with similar climate. An annual precipitation of 7.0 inches was used in both the HELP and LEACHM modeling as a measure of conservatism. The HELP model was able to use a stochastically varied precipitation record while the average precipitation record was used in sequential runs in LEACHM to bring the model to steady-state. Temperatures, average wind speed and quarterly relative humidity for the site were taken from values for Hanksville given in Climates of the States (1978). These climatic values are presented in Figure J-1. Weekly pan evaporation for the model was estimated from a variety of sources. A 1979 NCF study lists gross pan evaporation for the site as 110 inches. A general estimate from a large-scale map in the Handbook of Applied Meteorology lists lake evaporation as roughly 51 inches. These two sources tend to bracket the anticipated annual pan evaporation between 70 inches and 110 inches. Values of 90 inches/year and 70 inches/year were used in the LEACHM modeling with the distribution as shown in Figure J-1.

J.3 HELP Model

Several runs were made with the HELP model using a variety of layer sequences and weather conditions. A five-year period was simulated for each run and then the leakage through the barrier was averaged. The evaporation depth for the modeling was set at 20 inches and the SCS curve number (CN) for runoff calculations was set at 50 for the rock covered surface and 65 for the rock surface with the large voids filled with fines. Predicted depths of runoff were very small. It is unlikely that observable overland surface flow will occur on the tailings under typical conditions, although interflow or lateral drainage in the rock will likely occur during more severe events. Table J-1 presents a summary of model results for the runs. The left side of the table presents soil information for the five soil layers. The central portion of the table presents summary weather and lateral drainage information. The right side of the table presents pertinent model results for the five-year simulation period.

The top layer in the cover configuration was modeled as an eight-inch thick gravel layer with only vertical percolation. The second layer in the cover was the top 18 inches of the freeze/thaw barrier and was also a vertical percolation layer. The third layer in the cover was the bottom six inches of the freeze thaw barrier and was modeled as a lateral drainage layer. No lateral drainage was indicated in the modeling effort and therefore the lateral slope conditions did not impact the modeling effort. The fourth layer in the cover was the clay radon/infiltration barrier that was modeled as a soil liner. The bottom layer in the cover was the tailings which was modeled as a vertical percolation layer. Model restrictions prevent evaporation from the barrier or underlying layers, and this creates a situation where physical properties of the tailings have little or no effect on volume of infiltrate for these conditions.

Model run #1 is considered the baseline modeling run. The average annual infiltration through the barrier was 0.079 inches. This translates to approximately 0.06 gpm penetrating to the tailings over a 14 acre tailings area. Because the precipitation was set at a conservatively high value, and the layer sequencing rules prevented formulation of a scenario where there was lateral drainage in the rock, this is considered a conservatively high estimate of infiltration. Model run #2 assumes that enough fines have been deposited in the rock layer to change its properties to that of loamy fine sand. The resulting prediction of 0.07 inch/year infiltration (0.05 gpm over 14 acres), is slightly reduced from the baseline simulation. Additional simulations to examine the impact of potential variability in the properties of the freeze/thaw barrier used sandy loam and sand as the freeze/thaw barrier. This sensitivity analysis for the freeze/thaw barrier gives a range of infiltration from 0.017 gpm over 14 acres to 0.11 gpm over 14 acres.

J.4 LEACHM Model

The LEACHM model has a provision for running through a user specified number of cycles with the same input data. This was done on all runs until the drainage flux through the barrier layer and underlying tailings approached steady-state. Table J-2 presents the model results as well as input properties for the cover profile. The soil profile thickness was 2.55 meters. The individual layer thickness was maintained at 51 mm (2 inch). A comparison was made with several runs at varying thickness and the results indicated that the model was not sensitive to the thickness of tailings beneath the barrier as long as that thickness was greater than 2 feet and the barrier was less permeable than the tailings. With the barrier layer controlling the infiltration into the tailings, a steady-state flow through the barrier represents the flux that will eventually report to the base of the tailings. There may be considerable time lag before this infiltrate reaches the base, but any water that passes through the barrier and moves more than a few feet into the profile will eventually reach the base of the tailings.

Table J-2. LEACHM Model Run Summary

LEACHM Model Run	Layer	Layer Type	Density (g/cc)	Thickness (inch)	Hyd. Cond. (cm/s)	Annual Precip. (inch)	Annual Pan Evap. (inch)	Infiltration Through Barrier (inch)	Water Balance Error (inch)
1	1	Rock Mulch	1.46	8	1	7	90	0.007	0.067
	2	Freeze/Thaw Bar.	1.59	24	1.0E-003				
	3	Clay Radon Barrier	1.44	18	1.0E-007				
	4	Tailings	1.59	50.2	7.2E-004				
2	1	Rock Mulch	1.46	8		7	70	0.007	0.074
	2	Freeze/Thaw Bar.	1.59	24	1.0E-003				
	3	Clay Radon Barrier	1.44	18	1.0E-007				
	4	Tailings	1.59	50.2	7.2E-004				

No plants were assumed to be present in the modeling. Some sparse vegetative growth may develop on the tailings impoundment, but the exclusion of water usage by plants from the modeling should introduce a very slight measure of conservatism. It is not likely that the continued presence of some vegetative growth could be assured. Because the HELP model indicated that very little runoff would occur, and that no measurable lateral drainage would occur, no abstractions were made in the average annual precipitation of seven inches in 47 events that was used in the modeling.

J.4.l LEACHM Simulations

The layer sequencing and cover material properties for the LEACHM model were similar to those used in the HELP model. A total of 4 layers were modeled for the cover profile. The rock mulch hydraulic conductivity (permeability) was set at 1 cm/sec, which was larger than that used in the HELP model. The profile used in the modeling is included in Table J-2.

Previous experience with the LEACHM model has shown that there is some sensitivity to the hydraulic properties of a rock layer underlain by a soil layer. In modeling the cover configuration for the Shootaring Canyon tailings, this sensitivity manifested itself as water balance errors in the first few inches of the rock cover. A typical water balance was approximately 2 mm/year, which is substantially greater than the predicted depth of infiltration. In order to present a very conservative estimate of infiltration, the water balance error was added to the model prediction of infiltration to produce a maximum depth of infiltrate.

With an annual pan evaporation of 90 inches, the predicted annual flux through the barrier was approximately 0. 18 mm (0.007 inch) with a water balance error of approximately 1.7 mm (0.067 inch). Even with consideration of the error, the predicted annual infiltration through the barrier is 0.07 inch. With an annual pan evaporation of70 inches, the predicted annual flux through the barrier was approximately 0.18 mm (0.007 inch) with a water balance error of approximately 1.9 mm (0.074 inch). Table J-2 presents a summary of the LEACHM model runs.

J.5 Discussion

The HELP model and the LEACHM model appeared to provide reasonable predictions of the infiltration through the cover system. Both models indicated that predicted infiltration will be less than 0.08 inch/year (0.06 gpm over 14 acres). These predictions were with reasonably conservative assumptions of precipitation depth and removal of water by lateral drainage. Because of layer sequencing limitations in the HELP model and the lack of a runoff component in the LEACHM model, the modeling did not adequately account for water that will likely be removed by lateral drainage or runoff. The general conclusion of this analysis is that the infiltration through the cover is small and is expected to be less than 0.06 gpm for the tailings cell.

Because the tailings cell is underlain with a clay liner, there is a potential for accumulation of infiltrate. This has been addressed within Section 5 in the body of the report. No significant accumulation is expected.

J.6 References

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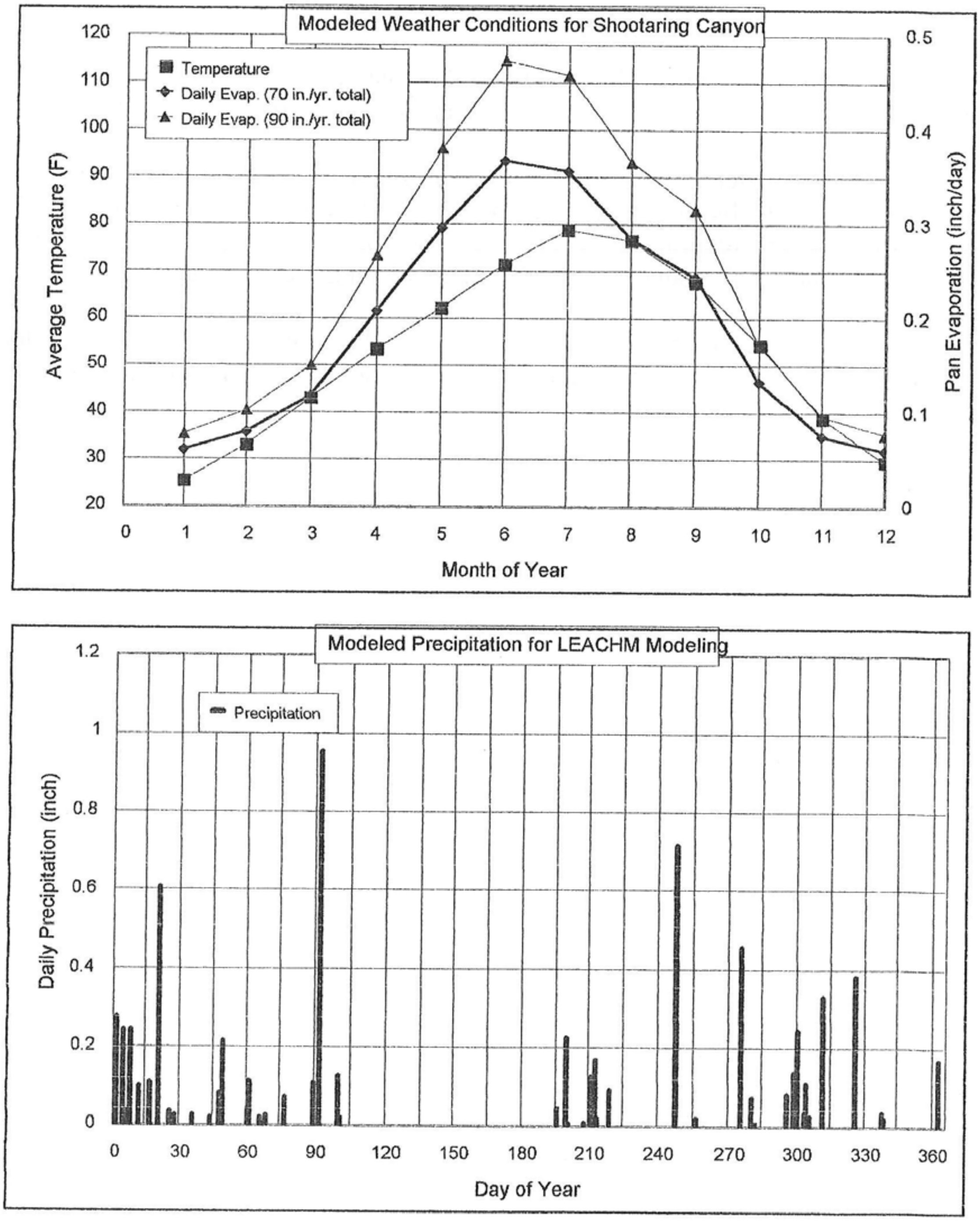

Figure J-1. Weather Summary

APPENDIX K

SUPPLEMENTAL HYDRAULIC ANALYSIS

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APPENDIX K
Supplemental Hydraulic Analysis

K.0 Introduction

In response to NRC comments of 12/24/02, some additional hydraulic and hydrologic analysis was done to address these comments.

K.l Runoff Modeling

The runoff modeling was conducted with HEC-1 model using the basin characteristics presented in Table 6-1 and the basins shown in Figure 6-1. The drainage area reporting to the major drainage channel is 141.3 acres. With the exception of the rock mulch outslope of the reclaimed cross valley berm and the immediate channel surface, precipitation on the south drainage basin falls outside of and downgradient of the erosion protection system for the tailings. The toe protection for the channel is the effective terminus of the erosion protection system for the encapsulated tailings. The toe protection is excavated to a depth of four feet in the base of the swale, and should contact the sandstone bedrock over much of the width of the swale. The Shootaring Canyon Dam is located approximately 800 feet downstream of this channel toe protection and is not considered an integral part of the erosion protection system. The dam is breached to reestablish the natural drainage in Shootaring Canyon and to prevent permanent ponding of significant quantities of water within the basin.

The runoff analysis described in Section 6.3 used the SCS curve number method to describe watershed conditions along with the PMP to produce a PMF analysis. The general curve number used for this analysis was a very conservative value of 88 for native areas and a conservative value of 80 for the basins with a large percentage of rock mulch area. These numbers incorporated antecedent moisture condition III, which resulted in large volumes of runoff and large peak flow for the erosion protection features in the immediate tailings area. The hydrographs were extracted from the HEC-1 output and the peak flows were used in channel rock sizing. Hydrographs for key channel locations are presented in Appendix D in Figures D-1 through D-5.

K.l.l Runoff Through the Shootaring Canyon Dam Breach

The configuration of the dam breach allows discharge at an elevation of 4374 feet above MSL. This elevation is approximately 12 feet lower than the elevation of the channel rock toe, so it is not plausible that backwater from the breach would encroach on the tailings. The configuration of the dam breach includes a very flat trapezoidal channel section with a base width of 20 feet and 2H: 1V side slopes. The downstream section of the breach includes a trapezoidal riprap channel section at a slope of 20%. The riprap will be taken from the dam face and is expected to have a D50 of approximately 24 inches. There are no specifications for this rock because this structure is not a part of the tailings erosion protection system. However, this configuration restricts the flow through

the breach and exploits the basin upstream of the dam as a large temporary surge pond, thereby greatly enhancing the erosional stability of this area. A brief hydrologic analysis was conducted for the breach by determining an approximate temporary surge pond volume for the basin upstream of the breach. The volume upstream of the Shootaring Canyon Dam was estimated at approximately 84 acre-feet up to an elevation of 4384 feet above MSL, which is slightly below the elevation of the end of the channel. An additional HEC-1 analysis was conducted using a SCS curve number of 68 for the entire basin and the PMP storm as presented in Figure 6-3. This curve number represents a well drained soil with a poor range condition at antecedent moisture condition II, and this is a reasonably conservative curve number for this site given the arid environment. The estimated peak discharge through the breach for this PMP event was 574 cfs with a total runoff volume of 87 acre-feet. The maximum stage upstream of the breach does not exceed 4376 feet above MSL. This is a small portion of the ten feet of pool elevation to toe of the outlet channel. The required rock D50 for the riprap according to the methodology described in Section 6.4.2 is 16.1 inches. Thus, the anticipated rock D50 of
24 inches is substantially oversized.

K.2 Water Surface Profiles

The water surface profile for the major channel is presented in Figure K-1. There is a 10:1 vertical exaggeration in the scales for this profile. This water surface profile corresponds to the alignment shown on Figure K-2 for the PMF with the PMP distribution shown in Figure 6-3. The HEC-1 model was used with level pool flood routing for the area above the porous rock ledge. The large size rock (D50 = 24 inches) in the porous rock ledge will allow complete drainage of runoff from the tailings area.

K.3 Rock Sizing

The rock sizing for both channel rock and rock mulch was done with the Abt/Johnson method as presented in NUREG 1623. The average unit discharge was used in both applications to determine the required rock size. A minimum oversizing of 50% was then applied to insure the adequacy of the rock size in nonuniform flow conditions. The oversizing also included oversizing for rock quality concerns and the specific gravity of the rock.

K.3.1 Rock Mulch Sizing

The overland flow paths shown on Figure 6-2 were used in determining the unit discharge for rock sizing by the Abt/Johnson method as presented in NUREG 1623. The following discussion provides a sample calculation for flow path 03-1 which is divided into two sections of relatively uniform slope labeled 03-1A and 03-1B. These calculations for al1 overland flow paths are summarized in Table 6-2.

Segment O3-1A: length= 60 feet, relief= 20 feet, slope = 0.20 ft./ft.

Time of Concentration by Kirpich's Method expressed as:

$t_c = 60*(11.9 * (length/5280)^3 / relief)^{0.385}$

$t_c = 60*(11.9 * (60/5280)^3 / 12)^{0.385} = 0.34$ minute

Since t_c is less than 2.5 minutes, the maximum intensity is 32.75 inch/hour (see Page 6-4).

The segment is on rock mulch so the runoff coefficient (C) is 0.8.

The Rational equation is used to calculate the segment discharge on a unit width basis as:

$q = C * I * A$

where: A= (length* 1 feet width) / (43560 ft^2/acre)

q = 0.8 * 32.75 * 60 / 43560 = 0.036 cfs/ft.

The rock D50 is calculated by the Abt/Johnson method expressed as:

$D50 = 5.23*q^{0.56}*slope^{0.43}$

$D50 = 5.23*(0.036)^{0.56}*(0.20)e^{0.43} = 0.41$ inch

The target minimum D50 for the rock mulch is 2 inches, so the rock mulch over sizing for this segment is:

Oversize = (2.00-0.41) / 0.41 * 100 = 388%

Segment 03-1B: length = 50 feet, relief= 4 feet, slope= 0.08 ft./ft.

Progressive Time of Concentration by Kirpich's Method expressed as:

$t_c = 60*(11.9 * (length/5280)^3 / relief)^{0.385}$

$t_c = 60*(11.9 * ((50+60)15280)^3 / (4+12))^{0.385} = 0.61$ minute

Since t_c is less than 2.5 minutes, the maximum intensity is 32.75 inch/hour (see Page 6-4).

The segment is on rock mulch so the runoff coefficient (C) is 0.8.

The Rational equation is used to calculate the segment discharge on a unit width basis as:
$q=C * I * A$

where: A= (length *1 feet width) / (43560 ft^2/acre)

$q = 0.8 * 32.75 * (60+50) / 43560 = 0.066$ cfs/ft.

The Rock D50 is calculated by the Abt/Johnson method expressed as:

$D50 = 5.23 * q^{0.56} * slope^{0.43}$

$D50 = 5.23 * (0.066)^{0.56} * (0.08)^{0.43} = 0.39$ inch

The target minimum *D50* for the rock mulch is 2 inches, so the rock mulch oversizing for this segment is:

$\text{Oversize} = (2.00 - 0.39) / 0.39 * 100 = 413\%$

The Manning's n was calculated by the Abt method and using in determining normal depth according to Manning's equation. These calculations are not used in the rock sizing for the rock mulch.

K.3.2 Channel Rock Sizing

The channel rock was sized at key locations using the Abt/Johnson method, the peak flows from the HEC-1 runoff modeling for the PMF, and the average unit discharge. A comparison rock size calculation was also done with the Stephenson method to insure the adequacy of the channel riprap. A constant Manning's n of 0.035 was used. Following rock sizing, a minimum oversizing of 50% based on the Abt/Johnson method was applied to all channel rock. This oversizing was well in excess of that required by rock quality scoring and compensates for minor deviation from the shear stress realized under a normal flow regime. These calculations are summarized in Table 6-3 for the channel hydrologic sections shown in Figure 6-6. Representative channel cross-sections are presented in Figures K-3 through K-5 for the locations presented on Figure K-2. A sample calculation is presented below.

Section HC-3: PMF Discharge = 2386 cfs.

Trapezoidal Channel – Base width = 30 feet
Right Side Slope (looking downstream) is 5H:1V
Left Side Slope (looking downstream) is 4H:1V

Manning's Equation is used to calculate the normal flow characteristics according to:

$$Q = (1.49 / n) A * R^{2/3} * S^{1/2}$$

Since the area of flow (A) and the hydraulic radius (R) are both functions of normal flow depth (y) and channel geometry, an iterative procedure is implemented in a spreadsheet to calculate y, A, R, the wetted perimeter (P), the top width (T), the average velocity (V), and the maximum velocity (Vm). The average unit discharge is calculated as:

$q = V * y = 14.14 * 3.639 = 51.45$ cfs/f

The rock D50 is calculated by the Abt/Johnson method expressed as:

$D50 = 5.23 * q^{0.56} * slope^{0.43}$

$D50 = 5.23 * (51/4)^{0.56} * (0.03)^{0.43} = 10.5$ inch = 0.88 feet

The target minimum D50 for the rock is 20 inches (1.67 feet), so the channel rock oversizing for this section is:

Oversize= $(1.67 - 0.88) / 0.88 * 100 = 90\%$

The Froude number (F) is calculated as:

$F = ((Q^2 * T)/(32.2 * A^3))^{1/2}$

$F = ((2386^2 * 62.75) / (32.2 * 168.8^3))^{1/2} = 1.52$

Flow is supercritical.

The Stephenson method, which was used for comparison rock sizing in channels, is expressed as:

$$D_{50} = \left[\frac{q (\tan\theta)^{7/6} n_p^{1/6}}{C g^{1/2} [(1 - n_p)(G_s - 1) \cos\theta (\tan\phi - \tan\theta)]^{5/3}} \right]^{2/3}$$

where:

D50= required rock diameter in feet, (50% of the rock must be larger than this),
q = flow rate per unit width,
θ= angle of channel bottom from horizontal,
p = angle of friction for the rock,
n_p = rockfill porosity,
G_s = specific gravity of the rock,
g = the acceleration of gravity, and
C = empirical factor which varies from 0.22
for gravel to 0.27 for crushed granite.

The assumption of uniform flow is implicit in the use of θ, the channel bottom angle. Since sin(θ) and tan(θ) are approximately equal to channel bottom slope expressed in rise/run, the channel bottom slope is often substituted for sin(θ) and tan(θ). A rockfill porosity of 0.325%, angle of repose of 42.2 degrees for the rock, C value of 0.27, and specific gravity of 2.5 were used in this calculation. The unit discharge of 51.4 cfs/ft and channel slope of0.03 feet/feet were used in calculating the rock size as:

$$D50= \left[\frac{51.4(\tan 1.718)^{7/6}\ 0.325^{1/6}}{0.27(32.2)^{1/2}[(1-0.325)(2.5-1)\cos 1.718(\tan 42.2 - \tan 1.718)]^{-5/3}} \right]^{-2/3}$$

$$D_{50} = 0.69 \text{ feet}$$

The rock size based on the Abt/Johnson method is slightly larger for this channel section and there is substantial oversizing incorporated.

K.3.2.1 Channel Rock Sizing in Bend

There is a gradual channel bend in the primary channel between stations 4+00 and 6+00 on Figure K-2. There is an increase in shear stress and required rock size in channel bends. However, the channel slope through the bend is reduced through the bend and this partially compensates for the increase in shear stress. This increased shear stress can be estimated using a method presented by USACOE, (1970). This method is based on Plate 34 of USACOE (1970), which is a figure relating the ratio of increased shear in bends to the ratio of channel bend radius divided by water surface width. The equation for this ratio of shear stress for smooth channels is given as:

$$\frac{\tau_b}{\tau_o} = 2.65(r/w)^{0.5}$$

where:

τ_b = maximum boundary shear in bend,
τ_o = average boundary shear,
r = center-line radius of channel bend, and
w = upstream water surface width of bend.

Unfortunately, this equation does not produce results that correspond with the figure in Plate 34 of USACOE (1970) and the correct form of the equation should be:

$$\frac{\tau_b}{\tau_o} = 2.65(w/r)^{0.5}$$

For rough channels, the plotted data indicates that the constant 3.1 should be substituted for the constant 2.65 in the preceding equation. However, there are only two data points for a very small r/w ratio (less than 1.6 for the incorrect form of the equation) to support the rough channel constant, and these values were determined from a two foot wide flume. Very little confidence can be placed in the increased constant (3.1) and the former version of the equation is considered more applicable. The Abt/Johnson method does not use shear stress directly in the calculation of rock size, but increasing the unit discharge is analogous to the increase in shear stress. The width of flow upstream of the bend is approximately 68 feet. The radius of the bend is approximately 250 feet, giving the ratio of shear stress as:

$$\frac{\tau_b}{\tau_o} = 2.65(w/r)^{0.5} = 2.65(68/250)^{0.5} = 1.3$$

The discharge through the section is 2368 cfs and the channel slope in the area of interest is approximately 0.047 feet/feet. The unit discharge as calculated by the Manning's equation and the methods described earlier is 39.61 cfs/foot. The rock D50 is calculated by the Abt/Johnson method using the product of the shear stress ratio and the unit discharge.

$$D50 = 5.23 * q^{0.56} * slope^{0.43} \qquad 3$$

$$D50 = 5.23 * (39.61)^{0.56} * (0.047)^{0.43} = 13.2 \text{ inch}$$

The target minimum D50 for the rock riprap is 20 inches (1.67 feet), so the channel rock oversizing for this section is:

$$\text{Oversize} = (1.67 - 1.10) / 1.10 * 100 = 52\%$$

K.4 Sedimentation

The reclamation surface for the tailings area includes slopes of 2% to approximately 20% with roughly five acres of off-tailings area contributing runoff to the rock mulch covered tailings surface. With the moderate slopes on the tailings, the potential for a significant depth of sediment accumulation above the rock mulch is very limited. It is likely that much of the pore space in the rock will eventually be filled with windblown sediment. However, once the rock mulch is covered, there will no longer be a stabilizing matrix to allow continued aggradation. The sediment above the rock will be highly erodible by both wind and runoff.

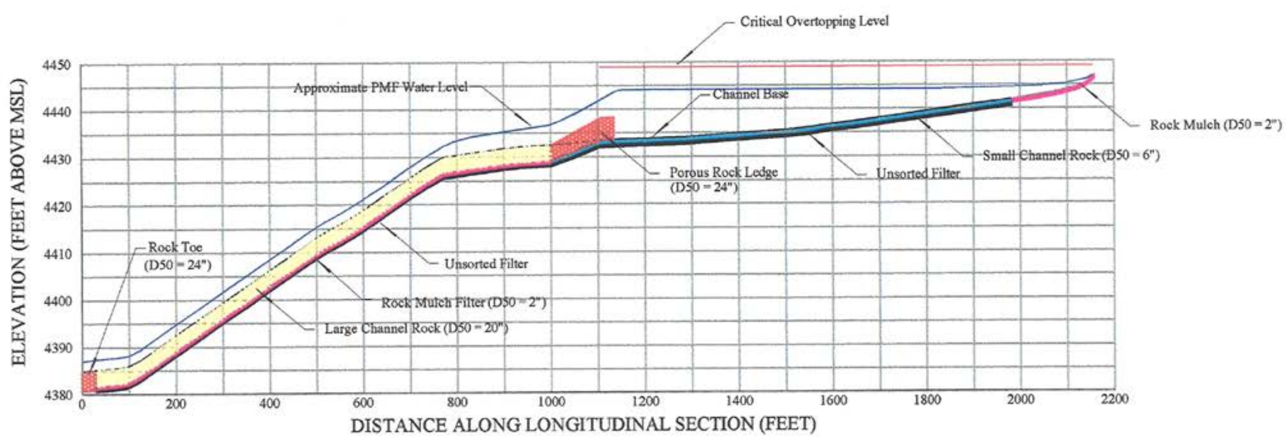
The potential sediment accumulation in the channel is discussed in Section 6.4.7. The primary feature that prevents any significant detrimental effects of sediment accumulation is the effective overtopping depth incorporated into the mildly sloping sections of channel. Figure K-1 presents the channel profile and includes a line showing the depth to which sediment would have to accumulate in order to overtop or otherwise divert the flow. The porous rock ledge is constructed of large enough rock that it will not function as a sediment dam. A sediment blockage in the section of mildest slope (between stations 9+00 and 13+00 on Figure K-2) would have to withstand the shear stress on a 3.5% to 4.5% slope in order to cause overtopping and this is extremely unlikely

K.5 Rock Mulch Apron

A twenty foot wide rock apron (see Figure K-6) is included at the perimeter of the rock mulch to transition to the surrounding surface. The rock for this apron is the 6 inch D50 rock specified for channel sections HC-1 and HC-2. The typical apron installation is on a milder slope than the upstream rock mulch (D50 = 2 inch). The three-fold increase in rock D50 for the apron is grossly conservative in that it will withstand flows several times greater than the PMF-designed rock mulch immediately upstream of it. At a slope of 5H:1V the 6 inch D50 rock will withstand a unit discharge of approximately 4.4 cfs/ft based on the Abt/Johnson method of rock sizing. This is several times greater than unit discharges presented in Table 6-2.

K.6. References

U.S. Army Corps of Engineers (USACOE), 1970, Hydraulic Design of Flood Control Channels, EM 1110-2-1601, Department of the Army, Office of the Chief of Engineers, Washington D.C.



HORIZONTAL SCALE: 1" = 300'
VERTICAL SCALE: 1" = 30'

URANIUM ONE AMERICAS

SHOOTARING CANYON URANIUM MILL SITE
TICABOO, UTAH

FIGURE K-1. WATER SURFACE PROFILES FOR DRAINAGE CHANNEL FROM TAILINGS CELL

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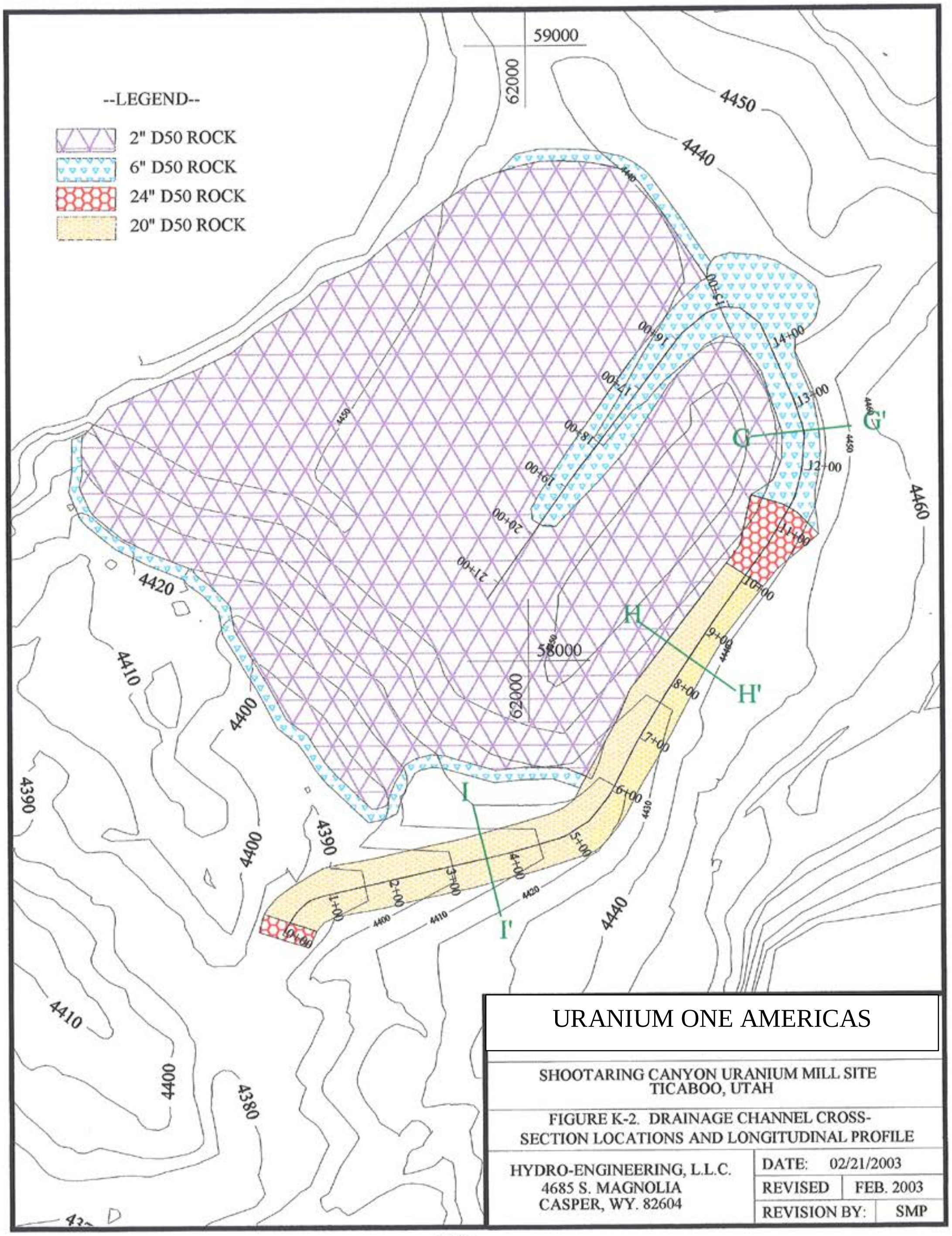
--LEGEND--
2" D50 ROCK
6" D50 ROCK
24" D50 ROCK
20" D50 ROCK
59000
62000
58000
4450
4440
4460
4420
4410
4400
4390
4380
G
G'
H
H'
I
I'
URANIUM ONE AMERICAS
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FIGURE K-2. DRAINAGE CHANNEL CROSS-SECTION LOCATIONS AND LONGITUDINAL PROFILE
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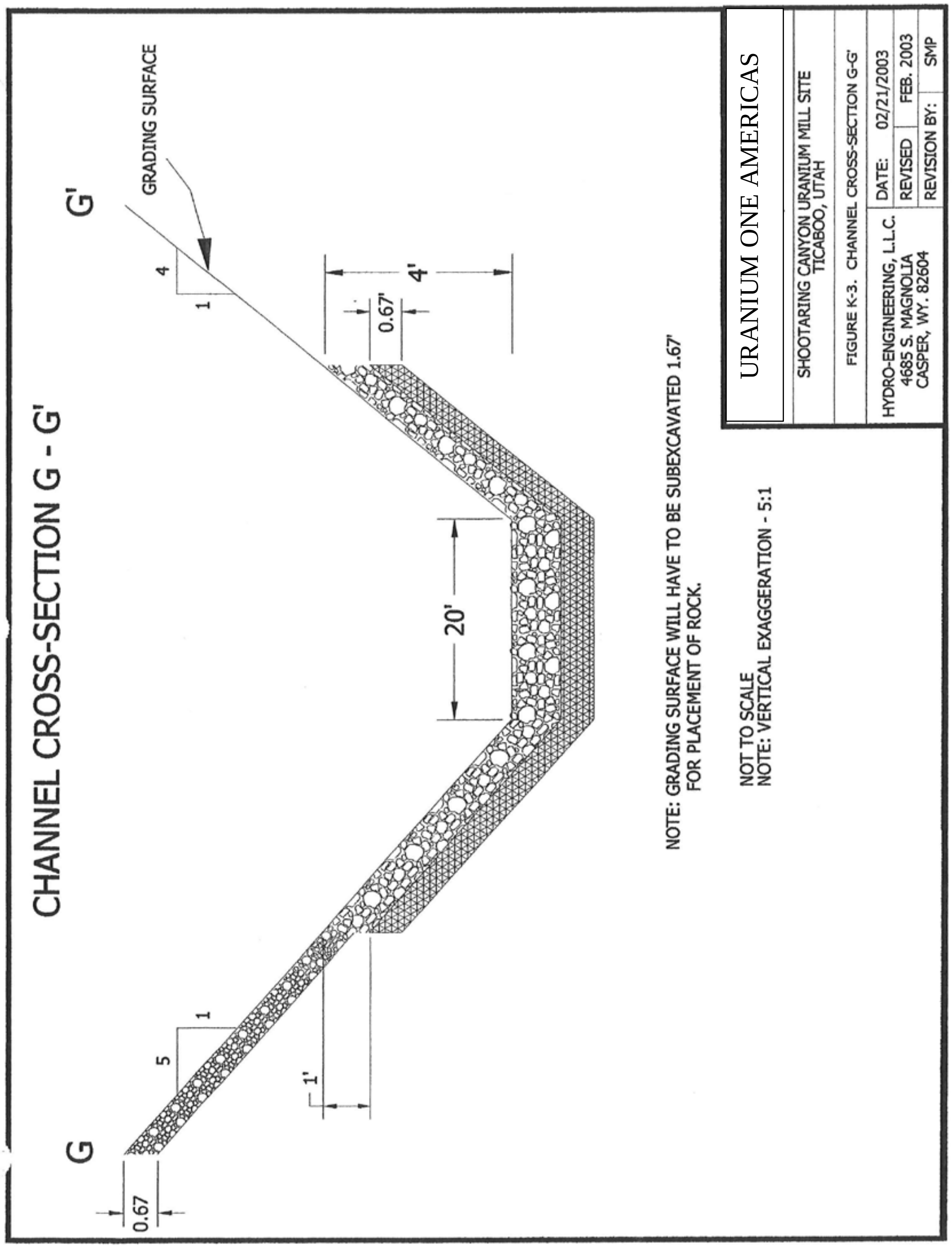
CHANNEL CROSS-SECTION G - G'
G
G'
GRADING SURFACE
0.67
5
1
1'
20'
4
1
0.67'
4'
NOTE: GRADING SURFACE WILL HAVE TO BE SUBEXCAVATED 1.67'
FOR PLACEMENT OF ROCK.
NOT TO SCALE
NOTE: VERTICAL EXAGGERATION - 5:1
URANIUM ONE AMERICAS
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FIGURE K-3. CHANNEL CROSS-SECTION G-G'
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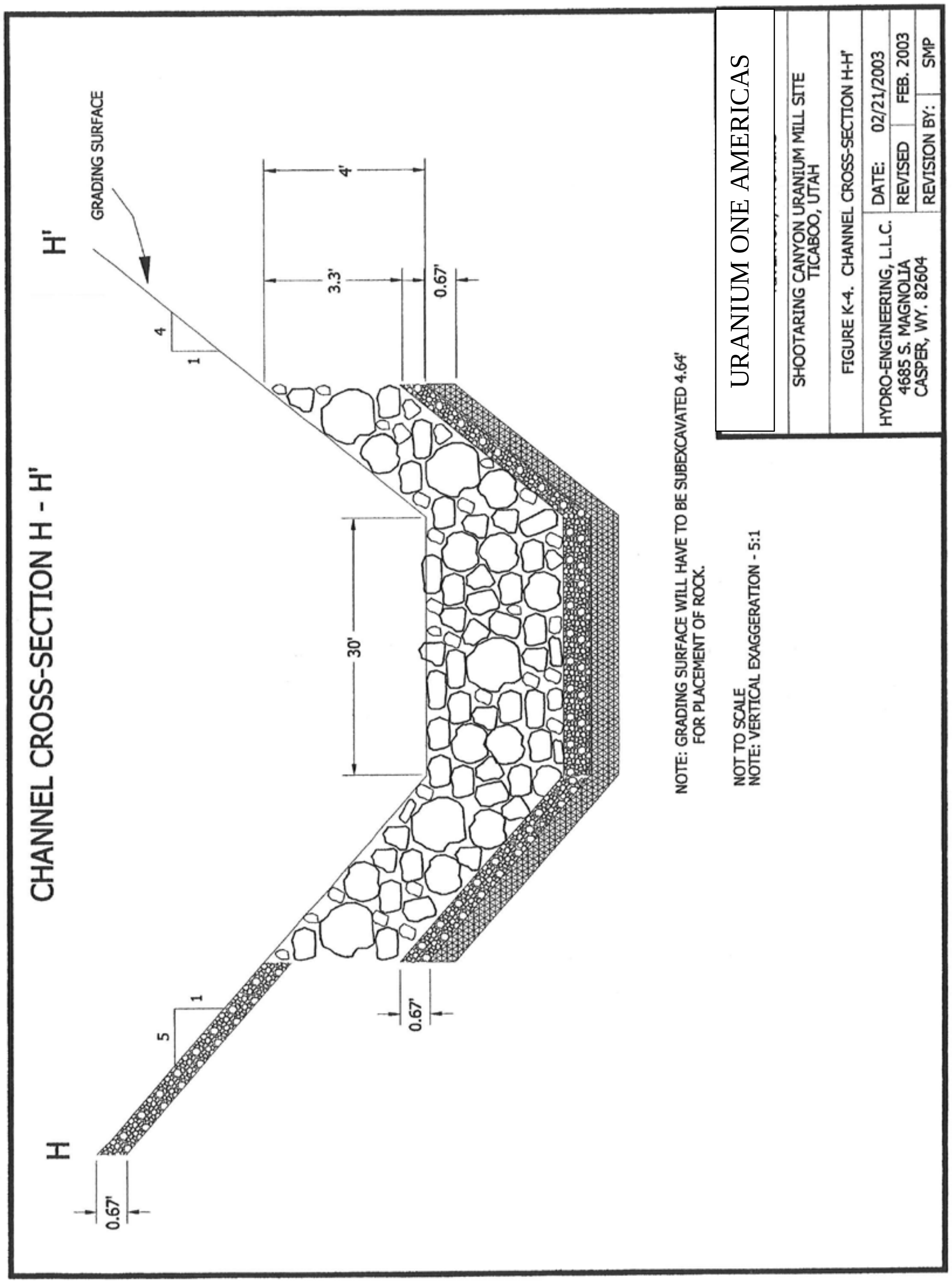
CHANNEL CROSS-SECTION H - H'
H
H'
GRADING SURFACE
4
1
5
1
0.67'
3.3'
4'
0.67'
30'
0.67'
NOTE: GRADING SURFACE WILL HAVE TO BE SUBEXCAVATED 4.64'
FOR PLACEMENT OF ROCK.
NOT TO SCALE
NOTE: VERTICAL EXAGGERATION - 5:1
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FIGURE K-4. CHANNEL CROSS-SECTION H-H'
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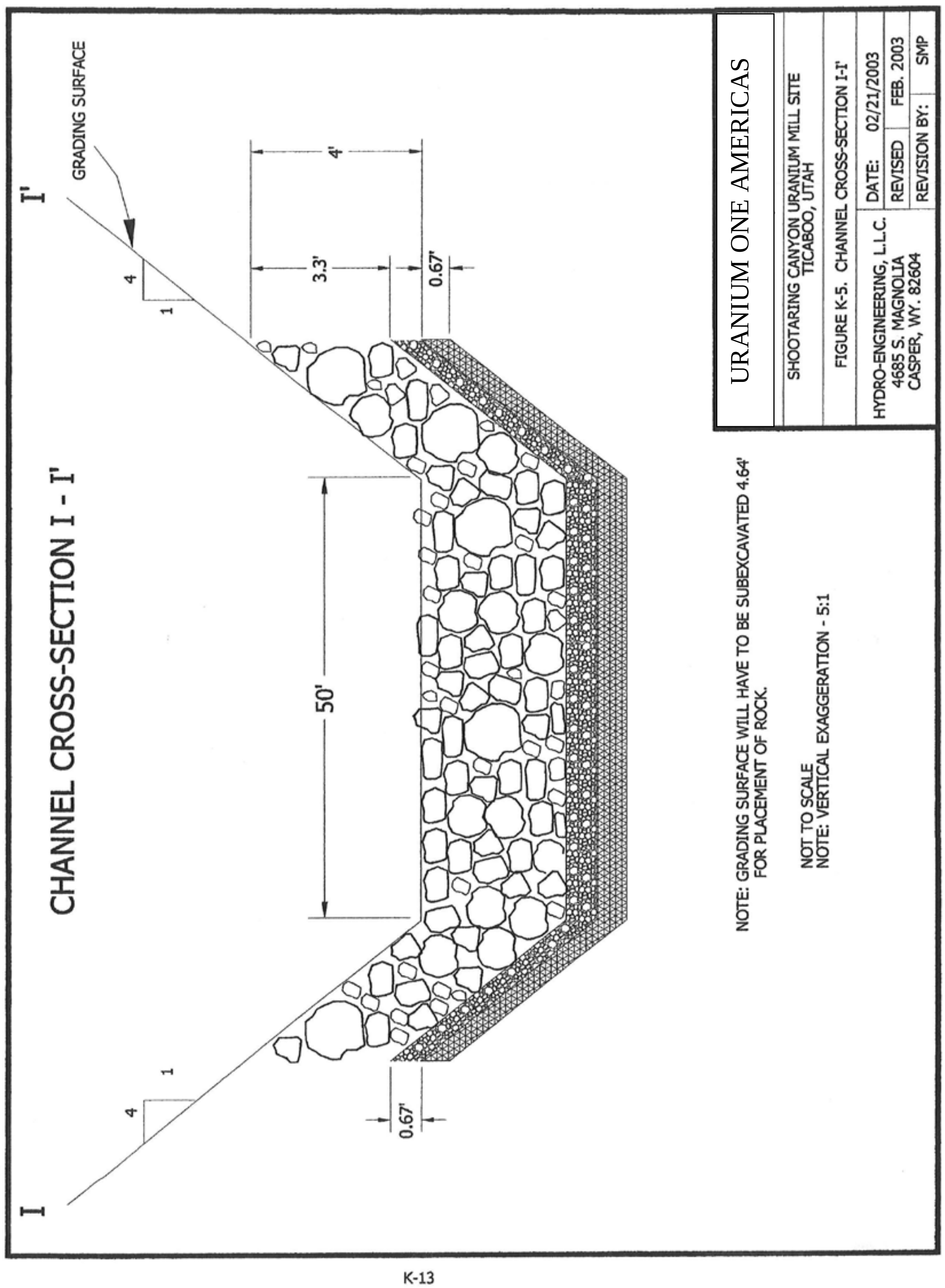
CHANNEL CROSS-SECTION I - I'
I
I'
GRADING SURFACE
4
1
50'
3.3'
4'
0.67'
NOTE: GRADING SURFACE WILL HAVE TO BE SUBEXCAVATED 4.64' FOR PLACEMENT OF ROCK.
NOT TO SCALE
NOTE: VERTICAL EXAGGERATION - 5:1
URANIUM ONE AMERICAS
SHOOTARING CANYON URANIUM MILL SITE
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FIGURE K-5. CHANNEL CROSS-SECTION I-I'
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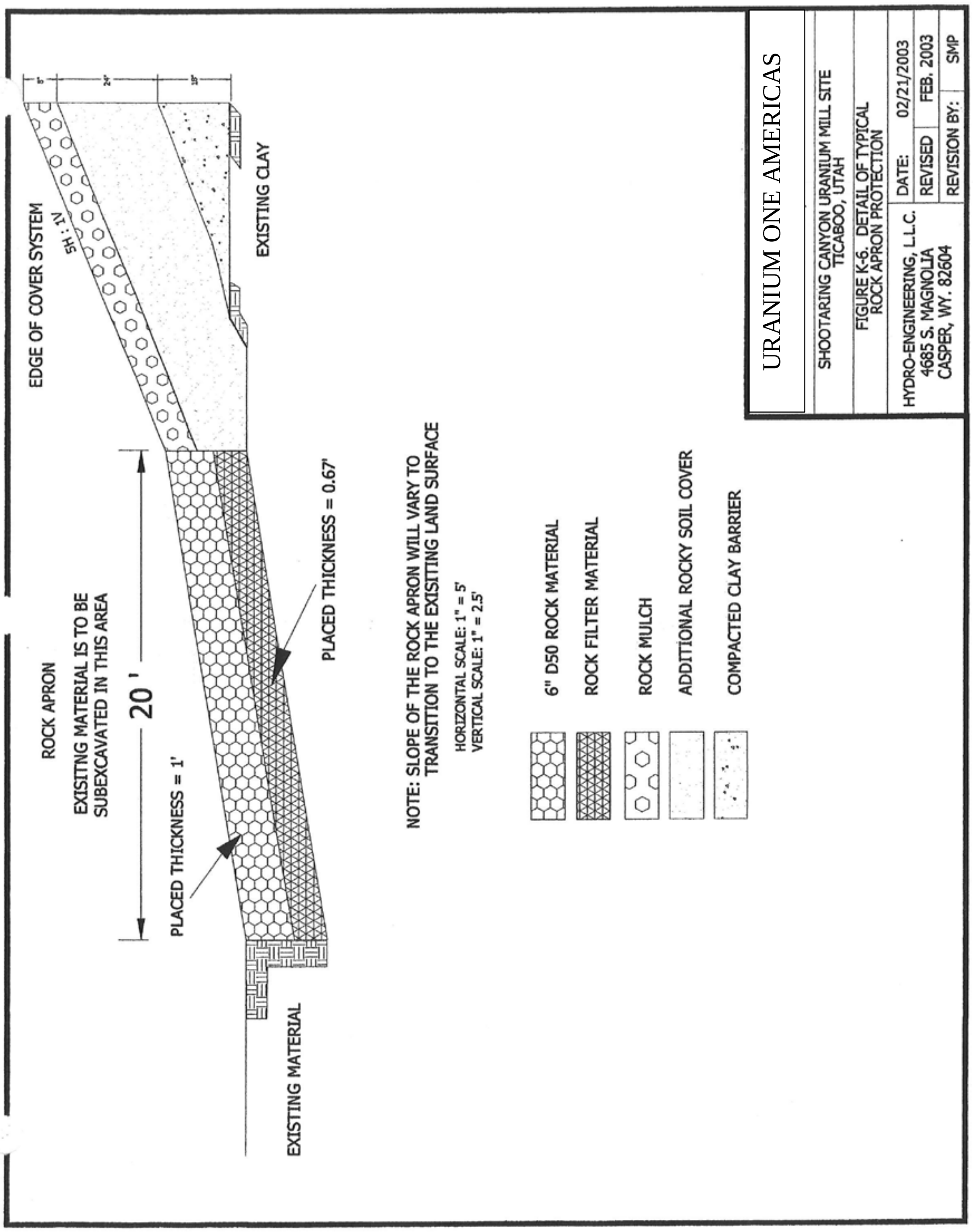
EDGE OF COVER SYSTEM
5H : 1V
EXISTING CLAY
ROCK APRON
EXISITNG MATERIAL IS TO BE
SUBEXCAVATED IN THIS AREA
20 '
PLACED THICKNESS = 1'
PLACED THICKNESS = 0.67'
EXISTING MATERIAL
NOTE: SLOPE OF THE ROCK APRON WILL VARY TO
TRANSITION TO THE EXISITING LAND SURFACE
HORIZONTAL SCALE: 1" = 5'
VERTICAL SCALE: 1" = 2.5'
6" D50 ROCK MATERIAL
ROCK FILTER MATERIAL
ROCK MULCH
ADDITIONAL ROCKY SOIL COVER
COMPACTED CLAY BARRIER
URANIUM ONE AMERICAS
SHOOTARING CANYON URANIUM MILL SITE
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FIGURE K-6. DETAIL OF TYPICAL
ROCK APRON PROTECTION
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