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Moab Site Project Completion Report Appendix Package

Interim Millsite Remedial Action Area

Work Performed by S.M. Stoller Corporation under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy Office of Environmental Management,
Grand Junction, Colorado

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1.0 Introduction and Background

The Moab Uranium Mill Tailings Remedial Action (UMTRA) Project Site (site) is a former uranium-ore processing facility located about 3 miles northwest of the city of Moab in Grand County, Utah. It is located on the west bank of the Colorado River at the confluence with Moab Wash. The site encompasses approximately 400 acres, of which approximately 130 acres are covered by a mill tailings pile.

In 2001 the Floyd D. Spence National Defense Authorization Act (act) was passed which required that the property title and the responsibility for cleanup be transferred from the Moab Mill Reclamation Trust to the U.S. Department of Energy (DOE). The act mandated remediation of the site in accordance with Title I of the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978. The site is managed by the DOE Office of Environmental Management.

After all areas of the site have been remediated, a final Moab Millsite completion report will be prepared to summarize all remedial action land verification activities at the site.

This Appendix to the final completion report summarizes the results of the remediation and radiological survey data of a portion of the site known as the Interim Millsite Remedial Action Area (IMRAA). The location is shown in Figure 1.

2.0 Basis for Remedial Action

Remedial action for the site has been conducted in accordance with UMTRCA; applicable provisions of the *Code of Federal Regulations* (40 CFR Part 192.12, Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings; and 40 CFR 192.22, Supplemental Standards); *Radiation Protection of the Public and the Environment* (DOE Order 5400.5); *Environment, Safety, and Health Program for Department of Energy Operations* (DOE Order 5480.1B); the National Environmental Policy Act (42 *United States Code* 4321); and all other applicable environmental regulations with an emphasis on maintaining all health and safety risks as low as reasonably achievable.

3.0 Cleanup Standards

3.1 Regulatory Standards

The cleanup standards, based on compliance with 40 CFR 192.12, are summarized in Table 1. This standard requires that the concentration of radium-226 (Ra-226) for the 0- to 15-centimeter (cm) soil layer must be 5 picocuries per gram (pCi/g) above background or less. Since the Ra-226 background for the site is 0.8 pCi/g (see Section 3.2), the cleanup standard is 5.8 pCi/g for surface soil. For soil layers deeper than 15 cm the requirement is that Ra-226 must be less than 15 pCi/g above background. So the cleanup standard is 15.8 pCi/g for subsurface soil layers.

Because thorium-230 (Th-230) decays to Ra-226, the Th-230 goals are based on a level of Th-230 that will ensure the site meets the Ra-226 standard over a 1,000-year performance period. The amount of Th-230 that can be left in place is dependent upon the amount of Ra-226 that is also left as shown in Table 1.

Table 1. Cleanup Standards

Remediation Goals				
	Surface (including background)		Subsurface (including background)	
Ra-226	5.8 pCi/g		15.8 pCi/g	
Th-230	Ra-226 (pCi/g)	Th-230 (pCi/g)	Ra-226 (pCi/g)	Th-230 (pCi/g)
	1.0	14.6	1.0	43.2
	2.0	12.7	2.0	41.2
	3.0	10.9	3.0	39.5
	4.0	9.0	4.0	37.6
	5.0	7.2	5.0	35.7
	5.8	5.8	6.0	33.9
			7.0	32.0
			8.0	30.2
			9.0	28.3
			10.0	26.5
			11.0	24.6
			12.0	22.8
			13.0	20.9
			14.0	19.1
			15.0	17.2
			15.8	15.8
Total Uranium (pCi/g)	Not applicable in this remediation area		Not applicable in this remediation area	

Assessment data shows Th-230 concentrations in this area ranged from 1.1 to 19.3 pCi/g. Uranium concentrations ranged from 1.0 to 39.0 pCi/g. The average ratio of Ra-226 to Th-230 was 1.3. The average ratio of Ra-226 to total uranium averaged 2.0. This indicates that the RRM is in secular equilibrium, so remediation activities to meet the Ra-226 cleanup standards will also reduce the Th-230 and uranium to levels that will ensure the site will not exceed the Ra-226 standard over the 1,000-year performance period specified in the standard.

3.2 Background Soil Radionuclide Concentrations

Soil radionuclide-concentration background values are summarized in Table 2. Background soil values for the site were determined from laboratory analysis of eight samples collected from offsite background locations in November 2001.

Table 2. Background Soil Radionuclide Concentrations

Criteria	Background Value
Radium-226 Concentration in Soil	0.8 pCi/g*
Thorium-230 Concentration in Soil	0.5 pCi/g
Total Uranium Concentration in Soil	1.2 pCi/g

*pCi/g = picocuries per gram

4.0 Description of Area of Remediation

The IMRAA includes approximately 95,551 square meters (m^2) (24 acres) located in the northeast corner of the millsite. Residual radioactive material (RRM) consists of uranium mill tailings and uranium ore. The area is crossed by a utility corridor containing fiber optic and electrical lines and three underground high-pressure gas lines. The utility corridor will be addressed in a separate supplemental standards application. One part of the IMRAA is separated from the main section by an office trailer complex. The remediation of the trailer complex will be discussed in a separate Appendix package.

The original property characterization is reported in the *Radiological Assessment for the Non-Pile Areas of the Moab Project Site* (DOE 2005). The areas and depths of contamination that were assessed for the IMRAA are shown in Plate 1.

5.0 Work Performed

5.1 Instrumentation

Gamma scintillometers were used to identify areas where elevated gamma levels indicate possible Ra-226 contamination. The types of scintillometers used included handheld Mount Sopris SC-132s, and Ludlum 44-10 sodium-iodide detectors mounted on an All-Terrain Vehicle (ATV) or in a backpack unit. Both types of scintillometers can be shielded (collimated) with lead around the sides of the detector. Collimated instruments were used to minimize elevated gamma (shine) caused by adjacent areas that were not yet remediated. Uncollimated instruments were used to maximize sensitivity for locating gamma anomalies. The ATV and backpack scintillometers were linked with a global positioning system (GPS) for mapping the location of the gamma measurements. These systems are referred to as gamma-scanning GPS (GS/GPS). The accuracy of the GPS for the ATV-mounted units is approximately plus or minus 4.6 m (15 ft.). The accuracy of the backpack-mounted units is approximately plus or minus 1 m (3 ft.)

Soil samples were analyzed on-site using sodium-iodide-based Opposed Crystal System (OCS) for Ra-226. Verification to the 40 CRF 192 soil standards was based upon the OCS data. In accordance with quality control procedures a minimum of 10 percent of the OCS verification samples were submitted to an analytical laboratory for quality control purposes.

Soil samples were also analyzed on-site for uranium using an Ortec Gamma Gauge© high-purity germanium (HPGe) detector. The HPGe is used for screening and is considered a semi-quantitative method.

Instrument procedures are included in *Field Services Procedures Manual* (STO 203). All instruments had daily operation checks performed in accordance with the *Field Services Procedures Manual* (STO 203).

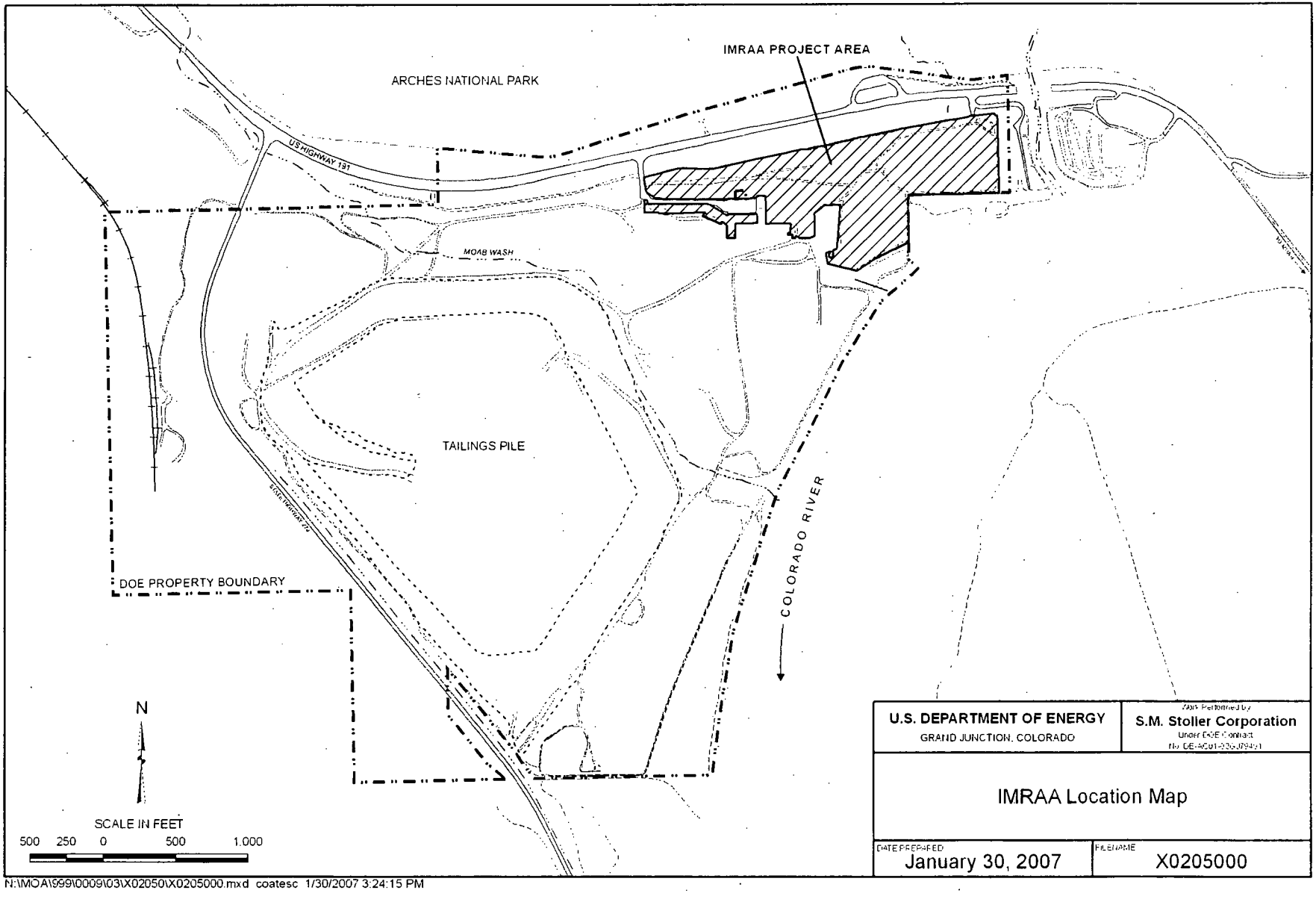

Figure 1. Site Location Map Showing the IMRAA Project Area

5.2 Characterization Survey Prior to Remediation

In order to determine which areas of the millsite required remediation to meet the cleanup standards, the millsite was characterized by S. M. Stoller between November 2001 and February 2005. A map of the areas and depths of assessed contamination within the IMRAA are shown in Plate 1 and discussed in the *Radiological Assessment for Non-Pile Areas of the Moab Project Site* (DOE 2005). That report also provides a description of the methods used to characterize the site. It was approved by the DOE and was submitted to the Nuclear Regulatory Commission (NRC) for review. Review comments received from the NRC were resolved prior to the start of remediation.

5.3 Remediation

Remediation began in February 2005 and was completed in January 2007. Surveys of the remediated areas were performed in accordance with the *Field Services Procedures Manual* (STO 203). After excavation to the previously assessed depth of contamination, the excavations were 100 percent gamma scanned with handheld SC-132 gamma scintillometers to locate any areas above the background gamma range that required further removal. Where required, excavation control soil samples were collected to further delineate areas for removal.

An abandoned septic tank and associated piping were removed from the area adjacent to and including parts of blocks V-LI-294 and V-LI-273. The final excavation to remove soil from around and beneath the former septic system was up to 3 m (10 ft) deep with benched sidewalls, making it inaccessible to ATV-mounted GS/GPS instruments. To verify cleanup, the sidewalls and floor of the excavation were scanned with handheld scintillometers, and a composite soil sample was taken from the pit (Table 4, sample V-LI-273A.) It is not known what buildings were originally served by the septic system.

The northeastern corner of the IMRAA, east of the main excavation area, was originally assessed as not contaminated and was not planned for remediation. During the characterization survey this area was heavily covered with tamarisk, and access was very difficult because the brush and trees were too thick to walk through. After remediation of the main areas the tamarisk was removed. Then the area was gamma scanned again to verify the original assessment. Scattered ore was found and was remediated. Excavation depths in this area were up to 61 cm (24 inches). Since the area had just been revegetated, the excavations were not backfilled and were left as shallow depressions and reseeded.

RRM that was removed from the IMRAA consisted of uranium mill tailings, uranium ore contaminated soil, and the contaminated septic tank and associated piping. Depths of removal ranged from 15 cm (6 inches) for surficial contamination to 3 (m) (10 ft) around the septic system. The contaminated material was stockpiled on site in the tailing pile area. After completion of the disposal cell at Crescent Junction, Utah, the material will be transported there for disposal.

5.4 Verification

Verification was based on meeting the 40 CFR 192 standards for Ra-226 concentrations in soil. Gamma scanning and soil sampling were used to verify that the cleanup standards were achieved. Areas of the IMRAA that are designated on Plate 1 and Plate 2 as "backfilled" were verified to the subsurface radium-in-soil standard of 15.8 picocuries per gram (pCi/g). All other areas were verified to meet the surface standard of 5.8 pCi/g.

5.4.1 Reference Grids

After excavation was complete, a predetermined grid measuring 210 m × 180 m was overlain on the verification area. The verification grid areas are identified by a "V" for verification plus two letters (e.g., grid V-ML). Each grid area was subdivided into 378 smaller verification blocks measuring 10 m × 10 m (100 m^2). Blocks are uniquely identified by the alphabetic identifier and location number within the larger grid (e.g., V-ML-370). Composite verification soil samples were collected from the verification blocks shown in Plates 1 and 2.

5.4.2 Gamma Scan Measurements

The accessible excavated surface was 100 percent scanned for gamma using both the handheld scintillometers and GS/GPS except in the septic system pit as noted in Section 5.3. To minimize the amount of soil sampling required, field personnel determined a range of gamma reading that were representative of the background in the excavated area. The background ranges are shown in Table 3.

Table 3. Verification Background Gamma Levels

Type of Measurement	Background Value
Collimated Surface 0–15 cm Excavation	3 to 7 µR/hr*
Collimated Subsurface >15 cm Excavation	4 to 10 µR/hr
Uncollimated Surface 0–15 cm Excavation	3 to 7 µR/hr

*µR/hr = microroentgens per hour

To determine the background ranges, the collimated GS/GPS data were used to calculate the average gamma for verification blocks where soil sampling showed the block meet the cleanup standard. The paired average gamma and Ra-226 soil results for the collimated data are shown in Table 4 and in Figures 1 and 2. The block locations are shown in Plates 1 and 2. The uncollimated surface data was collected during the rescan of the tamarisk area. Since this scan was prior to remediation, there is no associated soil data to use to calculate a background range. Instead, the collimated surface background range was used. Since an uncollimated measurement is always higher than a collimated measurement at the same location, using the collimated background is more conservative.

The results of the GS/GPS scans prior to backfilling and final grading are shown in Plate 2. The areas on Plate 2 which do not show gamma measurements are due to imprecision in the GPS locations. Plate 2 shows elevated gamma readings adjacent to the utility corridor and along the IMRAA project boundary. The elevated readings were investigated during remedial action and are due to contamination in the sidewalls of the excavation and in adjacent unremediated areas.

Future completion report appendix packages will demonstrate the reduction of gamma levels after remediation of the remaining adjacent areas. At a future date an application for the use of supplemental standards for the utility corridors will be submitted, because the risks and excessive costs associated with excavation of the area are expected to outweigh the benefits of remediation. After remediation of the IMRAA, clean backfill was used to cover the utility corridor to reduce the gamma levels.

5.4.3 Soil Measurements

After remediation the level of Ra-226 in soil was verified by collecting composite soil samples from selected 100 m^2 verification blocks. Composite samples were taken by dividing a block into approximately nine equal sub-blocks and then collecting an aliquot at the center of each sub-block. Soil samples were analyzed for Ra-226 by using the OCS method. The blocks were randomly selected by verification personnel to give a representative coverage of the remediated area. Some areas were sampled at a greater frequency while the background gamma range (Section 5.4.2) was being developed; or to verify that elevated gamma levels along the edges of excavations were due to shine from adjacent, unremediated areas.

The results of the OCS analyses for Ra-226 are provided in Table 4. There were 233 OCS soil samples collected, and 64 were submitted to Severn Trent Laboratories St. Louis (STL) or Paragon Analytics Laboratories for independent Ra-226 analysis. This exceeds the quality control guidance that 10 percent of the samples be submitted to an outside laboratory. STL analyzed Ra-226 by method EML GA-01-R MOD; Paragon Analytics Laboratories analyzed Ra-226 by method SOP713R8. Both methods are approved by DOE.

Table 4. Summary of Soil Data and Gamma Data After Remedial Excavation

Verification Block ID	Sample Ticket No.	Date Sampled	Sample Depth (cm)	OCS Ra-226 (pCi/g)	Laboratory Ra-226 (pCi/g)	Average Collimated Gamma*
V-KI-014	NEM 384	05/09/05	>15	1.87		15.1
V-KI-015	NEM 385	05/09/05	>15	1.92		
V-KJ-016	NEM 885	02/06/06	>15	2.01		7.2
V-KJ-037	NEM 891	02/06/06	>15	2.00		7.6
V-KJ-038	NEM 364	05/09/05	>15	2.50	1.76	6.1
V-KJ-040	NEM 319	05/09/05	>15	3.00	0.98	5.0
V-KJ-054	NEM 409	05/16/05	>15	3.30		
V-KJ-059	NEM 365	05/09/05	>15	1.80	2.38	5.6
V-KJ-075	NEM 908	02/13/06	>15	2.50		5.1
V-KJ-076	NEM 909	02/13/06	>15	2.60		6.1
V-KJ-077	NEM 896	02/13/06	>15	0.70		8.5
V-KJ-078	NEM 897	02/13/06	>15	1.30		7.7
V-KJ-098	NEM 898	02/13/06	>15	1.43		6.2
V-KJ-099	NEM 899	02/13/06	>15	1.89		5.7
V-KJ-100	NEM 366	05/09/05	>15	1.40		5.7
V-KJ-101	NEM 291	05/02/05	>15	5.61		6.1
V-KJ-103	NEM 320	05/09/05	>15	2.00	1.48	5.4
V-KK-001	NEM 309	05/09/05	>15	1.80	0.88	4.6
V-KK-008	NEM 274	05/02/05	>15	1.34		4.2
V-KK-023	NEM 310	05/09/05	>15	0.10	0.84	4.6
V-KK-044	NEM 311	05/09/05	>15	1.40	1.04	4.8
V-KK-064	NEM 312	05/09/05	>15	0.80	0.80	4.6
V-LH-124	NEM 110	03/14/05	>15	2.08	1.30	5.6
V-LH-144	NEM 107	03/14/05	>15	2.40	1.34	6.3

Table 4. Summary of Soil Data and Gamma Data After Remedial Excavation (continued)

Verification Block ID	Sample Ticket No.	Date Sampled	Sample Depth (cm)	OCS Ra-226 (pCi/g)	Laboratory Ra-226 (pCi/g)	Average Collimated Gamma*
V-LH-145	NEM 108	03/14/05	>15	3.50	2.00	5.7
V-LH-146	NEM 143	03/28/05	>15	3.10		5.8
V-LH-165	NEM 109	03/14/05	>15	0.43	1.68	8.4
V-LH-227	NEM 330	05/09/05	>15	1.61		7.5
V-LH-228	NEM 331	05/09/05	>15	12.40	15.7	7.3
V-LH-248	NEM 326	05/09/05	>15	2.50		7.9
V-LH-249	NEM 363	05/09/05	>15	1.39		7.5
V-LH-250	NEM 328	05/09/05	>15	1.30		7.0
V-LH-251	NEM 329	05/09/05	>15	1.20		7.2
V-LH-252	NEM 332	05/09/05	>15	0.74		7.2
V-LH-269	NEM 334	05/09/05	>15	1.33		7.5
V-LH-270	NEM 335	05/09/05	>15	1.80		9.3
V-LH-271	NEM 336	05/09/05	>15	1.20		10.9
V-LH-272	NEM 337	05/09/05	>15	1.50		10.7
V-LH-273	NEM 338	05/09/05	>15	2.10		7.7
V-LI-057	PAA 169	01/22/07	0 to 15	2.41		8.1
V-LI-103	NEM 178	04/11/05	>15	2.40		5.3
V-LI-124	NEM 179	04/11/05	>15	2.00		5.5
V-LI-145	NEM 180	04/11/05	>15	3.72		6.2
V-LI-166	NEM 181	04/11/05	>15	2.27		6.1
V-LI-209	NEN 390	08/14/06	>15	3.50		7.9
V-LI-210	NEN 296	08/14/06	>15	2.60		5.4
V-LI-230	NEN 391	08/14/06	>15	3.10		11.2
V-LI-231	NEN 397	08/14/06	>15	0.19		5.5
V-LI-232	NEM 340	05/09/05	>15	3.55		7.1
V-LI-233	NEM 341	05/09/05	>15	4.16		8.0
V-LI-234	NEM 345	05/09/05	>15	1.83		6.5
V-LI-235	NEM 346	05/09/05	>15	1.09		5.9
V-LI-236	NEM 347	05/09/05	>15	1.48		6.1
V-LI-237	NEM 348	05/09/05	>15	2.05		6.3
V-LI-238	NEM 349	05/09/05	>15	1.50		6.1
V-LI-239	NEM 350	05/09/05	>15	0.90		5.4
V-LI-240	NEM 351	05/09/05	>15	1.10		5.1
V-LI-241	NEM 352	05/09/05	>15	1.50		5.0
V-LI-242	NEM 353	05/09/05	>15	0.80		5.3
V-LI-251	NEN 392	08/14/06	>15	14.50		14.1
V-LI-252	NEN 298	08/14/06	>15	3.30		10.8
V-LI-253	NEM 342	05/09/05	>15	1.18		7.6
V-LI-254	NEM 343	05/09/05	>15	1.40		8.8
V-LI-255	NEM 344	05/09/05	>15	1.15		7.3
V-LI-256	NEM 355	05/09/05	>15	1.00		7.0
V-LI-257	NEM 356	05/09/05	>15	2.20		7.2
V-LI-258	NEM 357	05/09/05	>15	2.10		6.7
V-LI-259	NEM 358	05/09/05	>15	1.79		6.4
V-LI-260	NEM 359	05/09/05	>15	1.22		6.0
V-LI-261	NEM 360	05/09/05	>15	0.93		5.4
V-LI-262	NEM 361	05/09/05	>15	1.27		6.0
V-LI-263	NEM 362	05/09/05	>15	2.03		5.7
V-LI-264	NEM 367	05/09/05	>15	1.70		5.8
V-LI-272	NEN 394	08/14/06	>15	2.57		12.3
V-LI-273	NEN 393	08/14/06	>15	2.04		11.4
V-LI-273A	NEM 279	05/02/05	>15	2.90		11.4
V-LI-284	NEM 354	05/09/05	>15	3.30		8.4
V-LI-285	NEM 368	05/09/05	>15	3.10		6.3
V-LI-286	NEM 369	05/09/05	>15	2.90	2.91	6.8
V-LI-287	NEM 379	05/09/05	>15	3.60		6.6

Table 4. Summary of Soil Data and Gamma Data After Remedial Excavation (continued)

Verification Block ID	Sample Ticket No.	Date Sampled	Sample Depth (cm)	OCS Ra-226 (pCi/g)	Laboratory Ra-226 (pCi/g)	Average Collimated Gamma*
V-LI-288	NEM 380	05/09/05	>15	1.78		6.1
V-LI-289	NEM 390	05/09/05	>15	4.40	1.58	5.9
V-LI-290	NEM 391	05/09/05	>15	3.40		5.8
V-LI-291	NEM 392	05/09/05	>15	2.60		6.3
V-LI-292	NEM 393	05/09/05	>15	4.00		7.1
V-LI-293	NEN 401	08/21/06	>15	2.29		10.9
V-LI-294	NEN 402	08/21/06	>15	2.64		9.5
V-LI-306	NEM 370	05/09/05	>15	2.10		6.4
V-LI-307	NEM 371	05/09/05	>15	1.82		6.8
V-LI-308	NEM 381	05/09/05	>15	1.07		6.9
V-LI-309	NEM 382	05/09/05	>15	1.52		7.1
V-LI-310	NEM 386	05/09/05	>15	2.73		7.1
V-LI-311	NEM 387	05/09/05	>15	6.36		7.8
V-LI-312	NEM 388	05/09/05	>15	3.01		9.0
V-LI-312A	PAA 035	11/2/06	>15	4.124635		
V-LI-313	NEM 389	05/09/05	>15	5.86	4.94	9.0
V-LI-314	NEN 406	08/21/06	>15	5.70		10.0
V-LI-315	NEN 407	08/21/06	>15	1.80		8.3
V-LI-328	NEM 372	05/09/05	>15	1.17	0.44	5.9
V-LI-329	NEM 373	05/09/05	>15	4.30		7.8
V-LI-330	NEM 374	05/09/05	>15	2.50		7.5
V-LI-336	PAA 170	1/24/07	>15	2.08		
V-LI-350	NEM 375	05/09/05	>15	1.40		6.9
V-LI-351	NEM 376	05/09/05	>15	3.40		6.9
V-LI-371	NEM 377	05/09/05	>15	5.80		8.1
V-LI-372	NEM 378	05/09/05	>15	5.50		7.7
V-LJ-013	NEM 226	04/25/05	0 to 15	4.80	1.58	4.7
V-LJ-015	NEM 218	04/25/05	0 to 15	3.60	1.20	4.5
V-LJ-017	NEM 220	04/25/05	0 to 15	1.21	1.04	4.7
V-LJ-019	NEM 244	04/25/05	0 to 15	3.40	0.68	4.8
V-LJ-021	NEM 242	04/25/05	0 to 15	0.75	0.61	4.4
V-LJ-033	NEM 260	04/25/05	0 to 15	1.90	0.63	4.9
V-LJ-035	NEM 254	04/25/05	0 to 15	3.79	0.85	4.8
V-LJ-037	NEM 248	04/25/05	0 to 15	1.59	0.90	5.0
V-LJ-041	NEM 216	04/25/05	0 to 15	2.00	0.53	5.4
V-LJ-054	NEM 262	04/25/05	0 to 15	1.70	0.78	4.8
V-LJ-055	NEM 256	04/25/05	0 to 15	2.20	0.63	5.2
V-LJ-057	NEM 258	04/25/05	0 to 15	1.50	1.18	5.4
V-LJ-059	NEM 252	04/25/05	0 to 15	1.16	0.54	5.4
V-LJ-076	NEM 198	04/18/05	0 to 15	1.39		5.2
V-LJ-077	NEM 205	04/18/05	0 to 15	1.60	1.91	5.8
V-LJ-081	NEM 206	04/25/05	0 to 15	0.96	1.12	5.4
V-LJ-083	NEM 208	04/25/05	0 to 15	1.22	0.60	4.8
V-LJ-100	NEM 212	04/25/05	0 to 15	1.70	1.17	6.0
V-LJ-108	NEM 192	04/11/05	>15	1.70		4.9
V-LJ-128	NEM 193	04/11/05	>15	2.80		5.2
V-LJ-131	NEM 194	04/11/05	>15	1.60		5.6
V-LJ-139	NEM 195	04/11/05	>15	1.41		7.8
V-LJ-141	NEM 196	04/11/05	>15	0.93		9.6
V-LJ-157	NEM 197	04/11/05	>15	1.79		8.4
V-LJ-199	NEM 413	05/16/05	>15	2.00		4.8
V-LJ-203	NEM 411	05/16/05	>15	3.30		5.9
V-LJ-204	NEM 412	05/16/05	>15	2.10		8.9
V-LJ-212	NEM 394	05/16/05	>15	6.10		6.5
V-LJ-214	NEM 395	05/16/05	>15	2.10		4.5
V-LJ-216	NEM 400	05/16/05	>15	0.51		5.2

Table 4. Summary of Soil Data and Gamma Data After Remedial Excavation (continued)

Verification Block ID	Sample Ticket No.	Date Sampled	Sample Depth (cm)	OCS Ra-226 (pCi/g)	Laboratory Ra-226 (pCi/g)	Average Collimated Gamma*
V-LJ-218	NEM 401	05/16/05	>15	1.47		4.9
V-LJ-221	NEM 414	05/16/05	>15	3.00		4.6
V-LJ-223	NEM 415	05/16/05	>15	2.76		5.4
V-LJ-227	NEM 321	05/09/05	>15	1.90	1.65	7.6
V-LJ-231	NEM 313	05/09/05	>15	1.14	0.72	5.0
V-LJ-234	NEM 396	05/16/05	>15	3.40		6.6
V-LJ-236	NEM 402	05/16/05	>15	2.18		4.8
V-LJ-238	NEM 403	05/16/05	>15	1.16		4.5
V-LJ-241	NEM 404	05/16/05	>15	3.32		4.7
V-LJ-251	NEM 314	05/09/05	>15	1.24	1.32	5.9
V-LJ-254	NEM 397	05/16/05	>15	14.24		7.6
V-LJ-256	NEM 398	05/16/05	>15	1.60		5.1
V-LJ-258	NEM 406	05/16/05	>15	3.80		5.2
V-LJ-260	NEM 410	05/16/05	>15	2.60		5.3
V-LJ-261	NEM 405	05/16/05	>15	3.20		5.2
V-LJ-271	NEM 315	05/09/05	>15	2.12	1.43	6.4
V-LJ-276	NEM 399	05/16/05	>15	2.43		6.0
V-LJ-278	NEM 407	05/16/05	>15	2.70		5.8
V-LJ-280	NEM 408	05/16/05	>15	1.80		6.0
V-LJ-283	NEM 416	05/16/05	>15	1.69		4.7
V-LJ-294	NEM 316	05/09/05	>15	0.64	2.50	6.3
V-LJ-295	NEN 403	08/21/06	>15	2.67		9.3
V-LJ-298	NEN 404	08/21/06	>15	1.99		12.3
V-LJ-301	NEN 405	08/21/06	>15	1.70		9.7
V-LJ-314	NEM 317	05/09/05	>15	1.98	1.70	6.1
V-LJ-325	NEM 428	05/23/05	>15	0.93		5.3
V-LJ-333	NEM 322	05/09/05	>15	3.66	2.14	6.5
V-LJ-336	NEM 318	05/09/05	>15	2.24	1.58	5.7
V-LJ-345	NEM 417	05/16/05	>15	1.33		7.1
V-LJ-353	NEM 323	05/09/05	>15	2.80	4.06	5.7
V-LJ-367	NEM 429	05/23/05	>15	2.50		7.2
V-LJ-375	NEM 324	05/09/05	>15	1.07	1.05	5.5
V-LK-008	NEM 168	04/11/05	0 to 15	1.40		3.9
V-LK-011	NEM 169	4/11/05	>15	1.20		
V-LK-019	NEN 371	03/28/05	0 to 15	0.27		4.0
V-LK-022	NEM 250	04/25/05	0 to 15	1.90	0.63	4.5
V-LK-034	NEM 128	03/21/05	0 to 15	4.40		4.0
V-LK-035	NEM 129	03/21/05	0 to 15	2.10		3.9
V-LK-041	PAA 162	01/11/07	0 to 15	0.41		4.2
V-LK-045	NEM 147	04/04/05	>15	2.60		4.7
V-LK-046	NEM 146	04/04/05	>15	1.62		4.2
V-LK-066	NEM 148	04/04/05	>15	1.56		4.8
V-LK-067	NEM 150	04/04/05	>15	6.75		4.5
V-LK-068	NEM 152	04/04/05	>15	2.46		4.2
V-LK-072	NEM 170	04/11/05	0 to 15	1.80		4.5
V-LK-076	NEM 124	03/21/05	0 to 15	5.46		4.8
V-LK-085	NEM 210	04/25/05	0 to 15	1.60	0.78	4.9
V-LK-088	NEM 151	04/04/05	>15	7.60		5.0
V-LK-089	NEM 149	04/04/05	>15	4.50		4.4
V-LK-102	NEM 171	04/11/05	0 to 15	1.30		3.0
V-LK-110	NEM 153	04/04/05	>15	2.50		4.8
V-LK-111	NEM 155	04/04/05	>15	4.83		4.1
V-LK-132	NEM 157	04/04/05	>15	4.69		4.3
V-LK-133	NEM 159	04/04/05	>15	2.94		4.1
V-LK-138	NEM 173	04/11/05	0 to 15	0.79		3.3
V-LK-143	NEM 174	04/11/05	0 to 15	0.98		2.8

Table 4. Summary of Soil Data and Gamma Data After Remedial Excavation (continued)

Verification Block ID	Sample Ticket No.	Date Sampled	Sample Depth (cm)	OCS Ra-226 (pCi/g)	Laboratory Ra-226 (pCi/g)	Average Collimated Gamma*
V-LK-154	NEM 161	04/04/05	>15	1.25		4.5
V-LK-155	NEM 156	04/04/05	>15	1.70		4.1
V-LK-175	NEM 158	04/04/05	>15	4.20		5.0
V-LK-176	NEM 160	04/04/05	>15	0.70		4.2
V-LK-191	NEM 282	05/02/05	>15	1.10	0.57	4.4
V-LK-197	NEM 162	04/04/05	>15	2.20		4.4
V-LK-213	NEM 283	05/02/05	>15	2.40	0.68	4.1
V-LK-235	NEM 284	05/02/05	>15	3.40	0.52	3.9
V-LK-255	NEM 285	05/02/05	>15	0.77	0.532	3.8
V-LK-278	NEM 286	05/02/05	>15	2.77	1.43	3.9
V-LK-298	NEM 275	05/02/05	>15	3.28	0.66	3.8
V-LK-320	NEM 276	05/02/05	>15	2.15	1.29	4.3
V-LK-342	NEM 277	05/02/05	>15	4.30	1.15	4.1
V-LK-363	NEM 278	05/02/05	>15	4.40	1.56	4.2
V-LL-003	PAA 166	01/11/07	0 to 15	1.03		3.6
V-LL-029	NEM 093	02/07/05	0 to 15	3.50		
V-LL-169	NEM 091	02/07/05	0 to 15	2.30		5.6
V-MJ-333	NEM 238	04/25/05	0 to 15	0.81	0.48	4.6
V-MJ-335	NEM 240	04/25/05	0 to 15	2.20		4.5
V-MJ-351	NEM 230	04/25/05	0 to 15	3.30	0.63	4.4
V-MJ-353	NEM 236	04/25/05	0 to 15	1.26	0.49	4.5
V-MJ-355	NEM 232	04/25/05	0 to 15	3.20	0.96	4.3
V-MJ-369	NEM 224	04/25/05	0 to 15	2.38	0.976	4.7
V-MJ-371	NEM 222	04/25/05	0 to 15	3.80	1.52	4.9
V-MJ-373	NEM 228	04/25/05	0 to 15	1.68	0.86	4.7
V-MJ-375	NEM 234	04/25/05	0 to 15	1.83	0.60	4.2
V-MJ-377	NEM 246	04/25/05	0 to 15	0.53	0.81	4.5
V-MK-269	NEM 134	03/21/05	0 to 15	1.54		4.2
V-MK-287	NEM 175	04/11/05	0 to 15	0.80		4.3
V-MK-290	NEM 135	03/21/05	0 to 15	2.25		4.4
V-MK-294	NEM 136	03/21/05	0 to 15	0.05		4.0
V-MK-324	NEM 176	04/11/05	0 to 15	0.97		4.5
V-MK-334	NEM 137	03/21/05	0 to 15	0.09		3.5
V-MK-355	NEM 138	03/21/05	0 to 15	2.80		3.5
V-MK-367	NEM 177	04/11/05	0 to 15	0.92		4.1
V-ML-212	NEM 095	02/07/05	0 to 15	3.09		3.9
V-ML-214	NEM 096	02/07/05	0 to 15	1.58		4.1
V-ML-233	NEM 094	02/07/05	0 to 15	2.00		3.9
V-ML-234	NEM 097	02/07/05	0 to 15	1.49		3.9
V-ML-255	NEM 098	02/07/05	0 to 15	0.27		4.1
V-ML-276	PAA 163	01/11/07	0 to 15	0.21		3.7
V-ML-278	PAA 164	01/11/07	0 to 15	0.74		
V-ML-301	NEM 092	02/07/05	0 to 15	3.10		4.5
V-ML-316	PAA 165	01/11/07	0 to 15	0.29		3.5

* Average gamma is based on multiple collimated GS/GPS readings for the verification block.

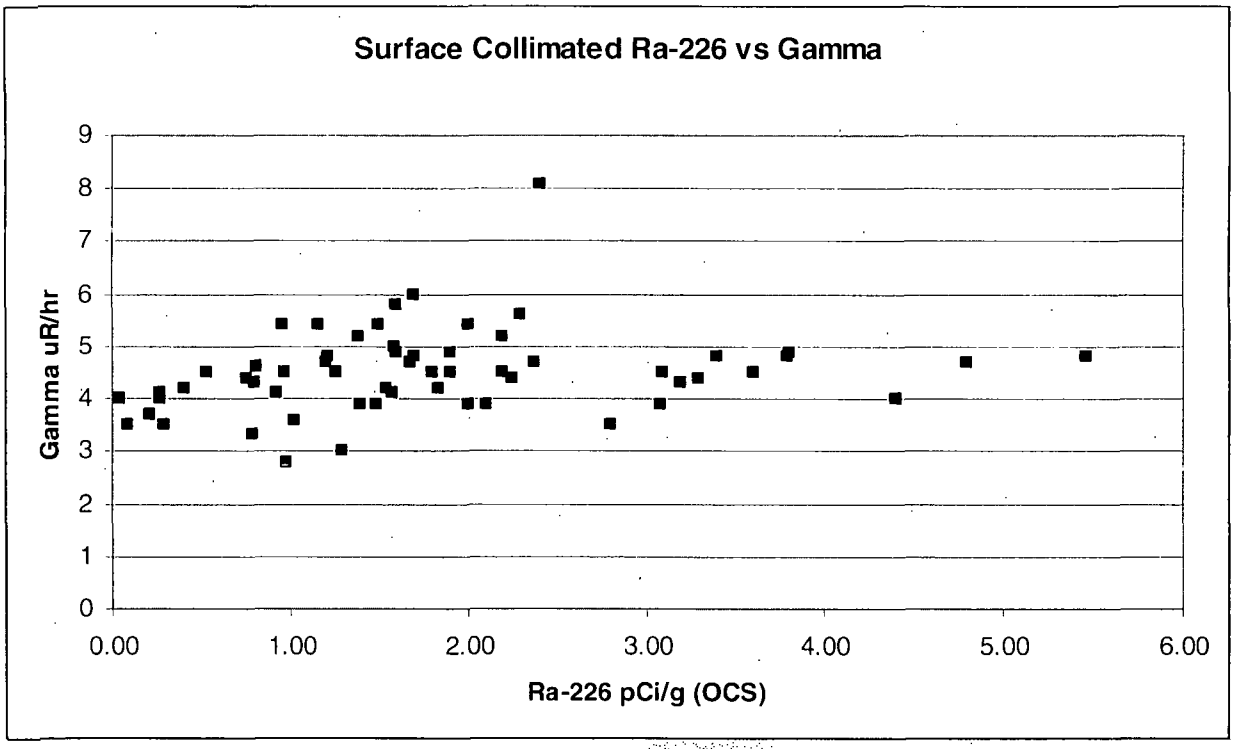

Figure 2. Collimated Data for Areas Verified to the Surface Standard

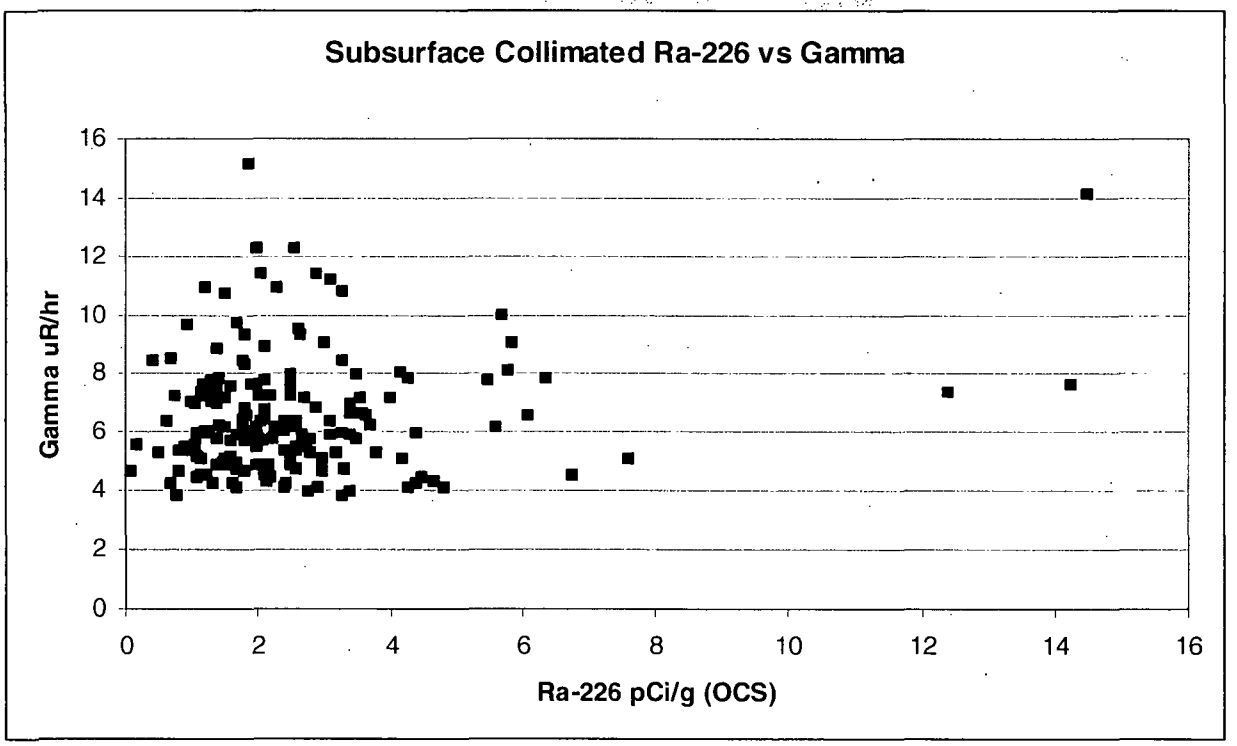

Figure 3. Collimated Data for Areas Verified to the Subsurface Standard

As indicated in Table 4, the laboratory analytical results validated the use of OCS for soil verification. The 64 verification samples measured by both the OCS and the independent laboratory averaged 2.37 pCi/g according to the OCS method and 1.46 pCi/g in the laboratory. Therefore, OCS results collected in the field can be considered conservative and are a valid verification measurement.

6.0 Final Condition

A summary of radiological results after remediation is provided in Table 5. Because of limitations of current technology and procedures for identifying and remediating RRM, unknown deposits of contamination may exist below the levels excavated during this remediation. After remediation the area was contoured and planted with native vegetation.

Table 5. Summary of Radiological Release Survey Results

Certification Criteria	Number of Observations	Cleanup Standard	Cleanup Standard Including Background[a]	Results[a] pCi/g
Ra-226 (pCi/g) Surface	61	Shall not exceed 5 pCi/g above background in the surface to 15-cm layer, averaged over 100 m^2	5.8	OCS Analysis Sample mean = 1.82 Maximum = 5.46 Std. dev = 1.19 $z_{95\%}$ = 1.645 $\mu_{95\%}$ = 2.07
Th-230 (pCi/g) Surface	2	Shall not exceed 5 pCi/g above background in the surface to 15-cm layer based averaged over 100 m^2	5.5	Laboratory Analysis Sample mean = 1.1 Maximum = 1.3
Ra-226 (pCi/g) Subsurface	175	Shall not exceed 15 pCi/g above background in any 15-cm-thick soil layer more than 15 cm below the surface, averaged over 100 m^2	15.8	OCS Analysis Sample mean = 2.56 Maximum = 14.50 Std. dev = 1.98 $z_{95\%}$ = 1.645 $\mu_{95\%}$ = 2.81
Th-230 (pCi/g) Subsurface	0	Shall not exceed 16 pCi/g above background in any 15-cm-thick soil layer more than 15 cm below the surface, averaged over 100 m^2	NA	NA
Uranium Surface	2	Not determined	Not determined	Laboratory Analysis Sample mean = 1.1 Maximum = 1.2
Uranium Subsurface	0	NA	NA	NA

Note: Th-230 and uranium values are from the characterization survey. No Th-230 or uranium samples were collected after remediation.

NA = not applicable
n = number of measurements
$z_{95\%}$ = z distribution statistic at 95% confidence (n=175 for > 15 cm, n = 61 for 0 to 15 cm)
$\bar{x}$ = sample mean
S = Std. Dev., the sample standard deviation
$\mu_{95\%}$ = upper limit of the true population mean at the 95 percent confidence level, using the following equation:

$$\mu_{95\%} = \bar{x} + z_{95\%} \frac{s}{\sqrt{n}}$$

6.1 Areas Verified to the Subsurface Standard (>15 cm)

The 40 CFR 192 cleanup standard for subsurface areas is 15.8 pCi/g Ra-226. For subsurface areas the maximum concentration was 14.50 pCi/g, which is below the cleanup standard (Table 5). The mean concentration was 2.56 pCi/g. The projected upper limit of the mean concentration, calculated at the 95 percent confidence level, was 2.81 pCi/g. These results indicate that the radionuclide concentrations do not exceed the cleanup standards; therefore, all cleanup criteria have been met for the areas verified to the subsurface standard.

All areas verified to the subsurface standard were backfilled with a minimum of 15 cm (6 inches) of with material with an average Ra-226 concentration of 2.8 pCi/g. Backfill soil sample results are shown in Table 6.

Table 6. Backfill Data

Sample Identification	Date Sampled	OCS Ra-226 (pCi/g)
1 East	6/13/05	3
1 West	6/13/05	3.7
2 West	6/13/05	2.7
3 West	6/13/05	2.8
4 West	6/20/05	4.4
X-LJ-023	5/2/05	1.9

6.2 Areas Verified to the Surface Standard

For areas verified to the surface standard, the maximum concentration of Ra-226 was 5.46 pCi/g, which is below the cleanup standard of 5.8 pCi/g (Table 5). The mean concentration was 1.82 pCi/g. The projected upper limit of the mean concentration, calculated at the 95 percent confidence level, was 2.07 pCi/g. These results indicate that the radionuclide concentrations do not exceed the cleanup standards; therefore, all cleanup criteria have been met for the areas verified to the surface standard.

6.3 Areas That Did Not Require Remediation

The millsite characterization (Section 5.2) demonstrated that some areas of the IMRAA were below the 40 CFR 192 cleanup standards and therefore did not require remediation. The data from these areas is shown in Table 7 and the locations are shown on Plates 1 and 2.

Table 7. Radium-226, Thorium-230, and Uranium Data in Areas that Were Not Remediated

Location	Sample Ticket No.	Date Sampled	Sample Depth (cm)	OCS Ra-226 (pCi/g)	Laboratory Ra-226 (pCi/g)	Laboratory Th-230 (pCi/g)	Laboratory Uranium (pCi/g)
R0595	NDO 812	06/25/02	0 to 15	4.21			
R0597	NDO 814	06/25/02	0 to 15	1.27			
R0598	NDO 815	06/25/02	0 to 15	1.47	0.76	1.3	1.0
R0599	NDO 816	06/25/02	0 to 15	1.22	0.61	1.1	1.2
R0624	NDO 825	06/26/02	0 to 15	1.49			

Note: Blank cells indicate no measurement for that analyte or by that method were taken.

7.0 References

40 CFR 192. EPA (Environmental Protection Agency), *Code of Federal Regulations*, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," March 2007.

42 U.S.C. 4321. EPA (Environmental Protection Agency), *United States Code*, "National Environmental Policy Act," January 2007.

DOE (U.S. Department of Energy), 2005a. *Radiological Assessment for Non-Pile Areas of the Moab Project Site* (DOE-EM/GJ901-2005), August.

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DOE (U.S. Department of Energy) 2006. *Moab UMTRA Project Emergency Response Plan*, (DOE-EM/GJ1085-2006), October.

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Order 5400.5 *Radiation Protection of the Public and the Environment*, February 1990.

Order 5480.1B *Environment, Safety, and Health Program for Department of Energy Operations*, September 1986.

STO 1. *Quality Assurance Manual*, continuously updated, prepared by S.M. Stoller Corporation for the U.S. Department of Energy, Grand Junction, Colorado.

STO 2. *Health and Safety Manual*, continuously updated, prepared by S.M. Stoller Corporation for the U.S. Department of Energy, Grand Junction, Colorado.

STO 3. *Site Radiological Control Manual*, continuously updated, prepared by S.M. Stoller Corporation for the U.S. Department of Energy, Grand Junction, Colorado.

STO 4. *Training Manual*, continuously updated, prepared by S.M. Stoller Corporation for the U.S. Department of Energy, Grand Junction, Colorado.

STO 5. *Construction Procedures Manual*, continuously updated, prepared by S.M. Stoller Corporation for the U.S. Department of Energy, Grand Junction, Colorado.

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STO 207. *Finance and Accounting Procedures*, continuously updated, prepared by S.M. Stoller Corporation for the U.S. Department of Energy, Grand Junction, Colorado.

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