Calendar Year 2019 ALARA Report for the Ambrosia Lake Site

June 2020

prepared for:

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Section 1.0 Site Activities

This report summarizes calendar year 2019 activities, occupational radiation dose monitoring results and public dose estimates at Rio Algom Mining LLC's (RAML's) Ambrosia Lake site (the Site). The Site is a former uranium mill currently being decommissioned. The Site is regulated by a specific radioactive materials license (License Number SUA-1473) issued by the Nuclear Regulatory Commission.

Much of the licensed material subject to site remediation has been consolidated in an engineered repository that was closed in 2016 following NRC approval.

Activities at the Ambrosia Lake site in 2019 consisted of 1) routine environmental monitoring, 2) a shielded gamma survey of the windblown tailings area (WTA) as it is described in the current Soil Decommissioning Plan (SDP), and 4) monitor well installation to support an amended alternate concentration limit (ACL) application with the Nuclear Regulatory Commission. The major activities for the year at the Ambrosia Lake site are summarized below.

1.1 1st Quarter

- Routine environmental monitoring including:
    - Groundwater sampling in and around the proposed Long-Term Surveillance Monitoring (LTSM) area
    - Radon-222 in ambient air at the seven locations shown on Figure 1

1.2 2nd Quarter

- Routine environmental monitoring as described in 1st quarter.

1.3 3rd Quarter

- Routine environmental monitoring as described in 1st quarter.
- In early July, RAML resumed the ACL drilling program that was postponed in December 2018. This program consisted of drilling of monitoring wells to collect information to support the site's alternate concentration limit (ACL) program.

1.4 4th Quarter

- Routine environmental monitoring as described in 1st quarter.
- The ACL drilling program started in the 3rd quarter was completed in the 4th quarter.

Section 2.0 Occupational Exposures to Ionizing Radiation – Summary

External doses from ionizing radiation were monitored for personnel working with and around licensed radioactive materials. The monitoring methods are identified in the Site's *Radiation Protection and Environmental Program Manual.* RAML's dose calculations are performed in a manner consistent with Nuclear Regulatory Commission (NRC) guidance described in USNRC Regulatory Guide 8.34, *Monitoring Criteria and Methods to Calculate Occupational Radiation Doses.* Internal doses from ionizing radiation were not evaluated since the largest sources of internal exposure have been mitigated and previous monitoring has demonstrated that internal doses from ionizing radiation are much lower than ten percent of applicable regulatory limit of a committed effective dose equivalent (CEDE) of 5000 rem per year. All applicable regulatory limits for occupation radiation doses are contained in 10 CFR 20.1201.

2.1 External Exposure to Ionizing Radiation

Optically stimulated luminescent dosimeters (OSLs) are used to monitor occupational exposure to ionizing radiation from external sources at the Ambrosia Lake site. In 2019, all site personnel and contractors providing environmental monitoring and health physics support are trained radiation workers and have assigned dosimeters that are required to worn while on-site. In addition, contract and RAML personnel conducting work related to the ACL program were monitored. The dosimeters allow determination of deep dose equivalent (DDE), eye lens dose equivalent (LDE), and shallow dose equivalent (SDE). Dosimeters (including control dosimeters) are stored in a background location (the site trailer) while personnel are not on-site. As a result, the measured external dose is from potential exposure to licensed radioactive material. Landauer's Luxel® OSLs were used to monitor external dose parameters for the monitoring period. Landauer reports that this dosimeter has a sensitivity of 1 mrem. All reported external doses are well below regulatory limits. Since 2000, the external doses at the Ambrosia Lake site have been low (typically less than 10 percent of regulatory limits). The data for the external doses in 2019 are tabulated in Tables 2.1 through 2.3. Since doses are less than 10 % of the applicable limits in 10 CFR 20.1201, workers are not required to be monitored per 10 CFR 20.1502. Likewise, a determination of prior occupational dose in 10 CFR 20.2104 is not applicable. RAML chooses to monitor workers to demonstrate occupational doses are as low as is reasonably achievable (ALARA).

2.1.1 Deep Dose Equivalent

In 2019, twenty-two individuals had DDEs exceeding the 1 mrem sensitivity of the Luxel® OSL. The highest dose was 9 mrem per year. The mean of reported dose above the sensitivity limit (measurable dose) was 4.3 mrem per year. The 2019 DDE results are well below regulatory standard of 5000 mrem per year and should continue to be minimal as additional sources of licensed material at Ambrosia Lake are abated. The dosimeters for the ACL monitored group in Table 2.1 were issued for the project duration encompassing approximately 5 months whereas the dosimeters for other monitored groups were exchanged quarterly.

Table 2.1 2019 Summary of Deep Dose Equivalent

Monitored Group	Number of Employees Monitored	Number of Employees with Measurable Dose	Mean Dose (mrem)[1]	% with measurable dose
RAML	4	0	<1	0
INTERA	12	0	<1	0
ERG	9	1	<1	11
ACL Project*	23	21	4.1	91
Total	**48**	**22**	**2.0**	**46**

***Some ERG and INTERA personnel performing routine monitoring also worked on the ACL project. Dosimeters for these personnel are included in the ERG and INTERA monitored groups.**

[1] Mean dose assumes values reported as less than dosimeter sensitivity level (1 mrem) is zero.

2.1.2 Shallow Dose Equivalent

In 2019, twenty-two individuals had SDEs exceeding the 1 mrem sensitivity of the Luxel® OSL. The highest dose was 8 mrem per year. The mean of reported dose above the sensitivity limit (measurable dose) was 4.4 mrem per year. The 2019 SDE results are well below regulatory standard of 50,000 mrem per year and should continue to be minimal as additional sources of licensed material at Ambrosia Lake are abated. The dosimeters for the ACL monitored group in Table 2.2 were issued for the project duration encompassing approximately 5 months whereas the dosimeters for other monitored groups were exchanged quarterly.

Table 2.2 2019 Summary of Annual Shallow Dose Equivalent

Monitored Group	Number of Employees Monitored	Number of Employees with Measurable Dose	Mean Dose [1] (mrem)	% with measurable dose
RAML	4	0	<1	0
INTERA	12	0	<1	0
ERG	9	0	<1	0
ACL Project	23	22	4.2	96
Total	**48**	**22**	**2.0**	**46**

***Some ERG and INTERA personnel performing routine monitoring also worked on the DSR and ACL project. Dosimeters for these personnel are included in the ERG and INTERA Monitored Groups.**

[1] Mean dose assumes values reported as less than dosimeter sensitivity level (1 mrem) is zero.

2.1.3 Lens Dose Equivalent

In 2019, twenty-three individuals had LDEs exceeding the 1 mrem sensitivity of the Luxel® OSL. The highest dose was 9 mrem per year. The mean of reported dose above the sensitivity limit (measurable dose) was 4.6 mrem per year. The 2019 LDE results are well below regulatory standard of 15,000 mrem per year. The dosimeters for the ACL monitored group in Table 2.3 were issued for the project duration encompassing approximately 5 months whereas the dosimeters for other monitored groups were exchanged quarterly.

Table 2.3 2019 Summary of Lens Dose Equivalent

Monitored Group	Number of Employees Monitored	Number of Employees with Measurable Dose	Mean Dose[1] (mrem)	% with measurable dose
RAML	4	0	<1	0
INTERA	12	0	<1	0
ERG	9	1	<1	11
ACL Project	23	22	4.5	96
Total	**48**	**23**	**2.2**	**48**

***Some ERG and INTERA personnel performing routine monitoring also worked on the DSR and ACL project. Dosimeters for these personnel are included in the ERG and INTERA Monitored Groups.**

[1] Mean dose assumes values reported as less than dosimeter sensitivity level (1 mrem) is zero.

2.1.4 Summary of External Exposure to Ionizing Radiation

External doses due to ionizing radiation exposure were very low compared to the applicable regulatory limits. Most personnel working on the ACL project had doses reported above the sensitivity limit of 1 mrem. This was likely due to the extended wear period (5 months) where the other monitored groups the dosimeters were exchanged quarterly. For the other groups, a measurable dose equivalent above 1 mrem per year was limited to 1 person. The remainder of the monitoring data was below Landauer's sensitivity limit of 1 mrem per year. All doses reported are well below any regulatory limit.

2.2 Long-lived Radionuclide Intake Analysis

RAML did not conduct BZ monitoring for routine activities at the Site, such as environmental monitoring and inspections, since it has been shown previously that these types of activities do not result in internal doses greater than 10% of the applicable limit.

Non-routine activities included the drilling as part of the ACL program and the shield gamma survey of the WTA. Breathing zone samples of personnel performing the shield gamma survey were not collected since this activity was non-invasive and not expected to create an airborne radionuclide hazard. Breathing zone samples of personnel involved with the ACL program were not collected since data collected in 2018 as part of this program were very low and soil sampling of the alluvium where the drilling program occurred in 2019 showed low levels of radionuclides.

The evaluation of the near surface radionuclide concentrations at drilling locations, including field and analytical data, is provided in Appendix A.

2.2.1 Committed Dose Equivalent (CDE) to the highest exposed organ.

No estimate of CDE was made since no occupational long-lived air samples were collected. As such, no internal dose was calculated and assigned to project personnel.

2.2.2 Committed Effective Dose Equivalent (CEDE) Summary.

No estimate of CEDE was made since no occupational long-lived air samples were collected. As such, no internal dose was calculated and assigned to project personnel.

2.3 Total Effective Dose Equivalent (TEDE) Summary

The TEDE is the sum of the internal dose component (CEDE) and the external dose component (DDE). All TEDE estimates for 2019 based on personnel monitoring data are less than 10% of any applicable limit.

2.4 Bioassay Summary

Routine bioassay was discontinued in 2017 since all sources of soluble uranium at the Site have been mitigated. Future bioassay monitoring will be driven by the requirements of RWPs issued for a specific task. In 2019, there were no RWPs that required bioassay sampling.

2.5 Radiation Work Permit Summary

One RWP was issued in 2019. The RWP was issued to transfer oversized contaminated investigation derived waste (IDW) generated from the 2018 Dam Safety Review program from a High Density Polyethylene wrapped package to a plastic lined roll-off container. This activity lasted one day.

2.6 Contamination Surveys-Personnel and Equipment

Personnel who access the LTSM or perform other activities that may result in contamination perform self-scanning before leaving the site. Scanning techniques are reviewed and demonstrated in annual radiation safety training.

No elevated surface activity from self-scanning was reported in 2019.

Periodic equipment surveys for unconditional radiological release are performed for equipment that has potentially been exposed to licensed material. These surveys are documented with records maintained in the RAML Grants office or the site trailer. Most of the equipment released was associated with the ACL project occurring in the 3rd and 4th quarters of 2019. In 2019, all equipment for release was successfully decontaminated to meet criteria described in condition 25 of SUA-1473.

2.7 Safety and Training Activities

Annual radiation safety training, as outlined in Section 3.1 of the *2018/2019 Radiation Protection and Environmental Program Manual*, was completed for all employees and contractors and included the topics as outlined therein.

2.8 Audits and Inspections

An annual audit conducted by the radiation safety officer of the radiation protection program was performed in August of 2019. No deviations from the *2018/2019 Radiation Protection and Environmental Program Manual* or SUA-1473 were identified

Period inspections of the Site to ensure that radiation protection practices are being properly practiced and that the site fences and gates are secure and properly posted are being conducted by the RSO or the RSO designee. The inspection frequency was changed to

1) monthly, when site activities consist of invasive or non-routine work, or
2) quarterly, when site activities consist solely of routine environmental monitoring or other non-invasive work.

Section 3.0 Public Dose Evaluation

In addition to the occupational exposures discussed above, RAML annually evaluates radiation doses resulting from its operations to members of the public. These are prepared per the requirements of 10 CFR 20.1301-1302 and 40 CFR 190.10.

RAML submits semi-annual Effluent Reports to the NRC. The first half semi-annual report for 2019 was submitted on August 28, 2019 (NRC accession number ML19246A104). The second half report for 2019 was submitted on February 18, 2020 (NRC accession number ML20054A402). Data contained within these reports were used to evaluate doses to members of the public. Beginning January 1, 2018 (NRC accession number ML17293A342), the only environmental monitoring RAML conducted was measurement of radon-222 in air. As such, radiation doses to members of the public include only the radon-222 inhalation pathway.

Radiation dose is calculated to three hypothetical members of the public: the nearest resident (data from location Section 17 VH4 were used for point of exposure [POE] concentrations), a typical delivery driver (data from location Section 30 West VH6 were used for POE concentrations), and the occasional visitor, who might spend some time near the boundary of the Site property, such as a hunter or rancher (an average of all site monitoring data, except the Substation was used for POE concentrations). The Substation location is considered background. These monitoring locations are shown on Figure 1.

Dose conversion factors in 10 CFR 20, Appendix B, Table 2 were used to estimate public dose. Occupancy factors of 1, 0.0071, and 0.0128 were used for the nearest resident, delivery driver, and visitor respectively. A radon-222 decay product equilibrium fraction of 0.5 for indoor and 0.70 for outdoor exposure was assumed to calculate the dose from radon-222 and its decay products.

The 2019 results for dose to member of the public are shown in Table 3.1.

Table 3.1 2019 public dose estimate (mrem) for hypothetical public receptors near the Ambrosia Lake site.

Dose Source	Nearest Resident	Delivery Person	Visitor
Radon-222	0.0[1]	5.6	5.4
Total	**0.0**	**5.6**	**5.4**

[1] Net dose to the Nearest Resident was negative since net radon concentration was negative. Negative dose was reported as zero.

The table shows that the potential dose calculations for members of the public for 2019 were well below the 10 CFR 20.1301 dose limit of 100 mrem per year. Radon-222 and its progeny are excluded from dose limits in 40 CFR 190.10.

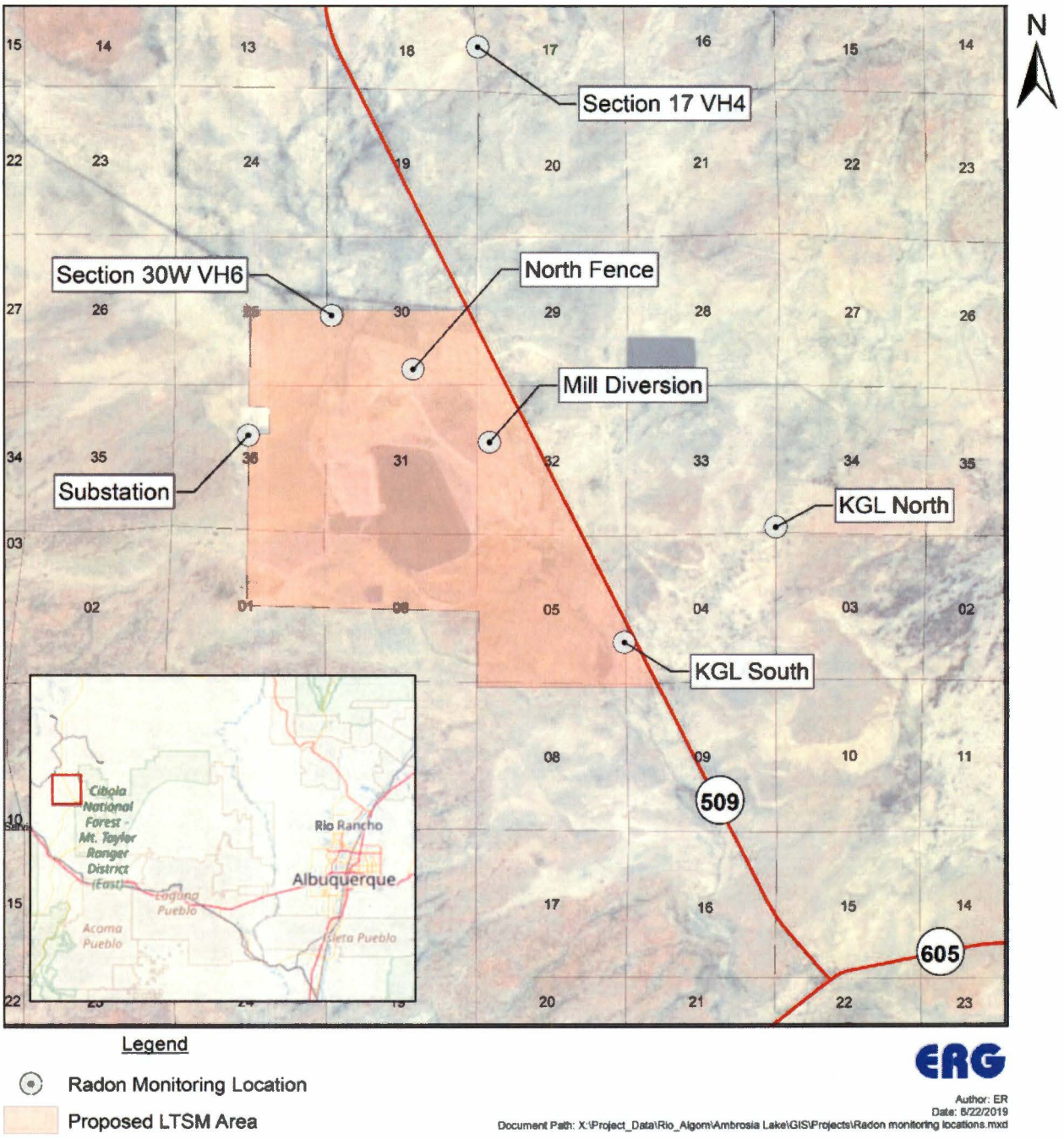

Figure 1. Location of radon-222 monitoring sites for the Ambrosia Lake Site.

Appendix A

Results of Prospective Drill Pad Vertical Profiling in Support of Ambrosia Lake ACL Drilling Program

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Memo

To: Ryan Schietinger, Principal Project Engineer, Rio Algom Mining LLC

From: Liz Ruedig and Mike Schierman (RSO)

cc: Kent Applegate, Principal, and Sandra Ross, Site Manager, Rio Algom Mining LLC

Date: 6/11/2020

Re: Results of Prospective Drill Pad Vertical Profiling in Support of Ambrosia Lake ACL Drilling Program

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Vertical profiling was performed at five drill pads within Rio Algom Mining LLC's (RAML's) Ambrosia Lake West Long Term Surveillance and Maintenance (LTSM) boundary (Site), to determine worker health requirements during RAML's 2019 Alternate Concentration Limit (ACL) drilling program.

Each drill pad was excavated in six-inch intervals using a hand auger to refusal. Gamma readings of each 6-inch soil core were made in the field prior to selecting soil samples for analysis at an independent laboratory. Once laboratory analysis was completed, ERG reviewed the analytic results and created a statistical model relating in-field gamma readings and gamma emitting radionuclide concentration in the soil.

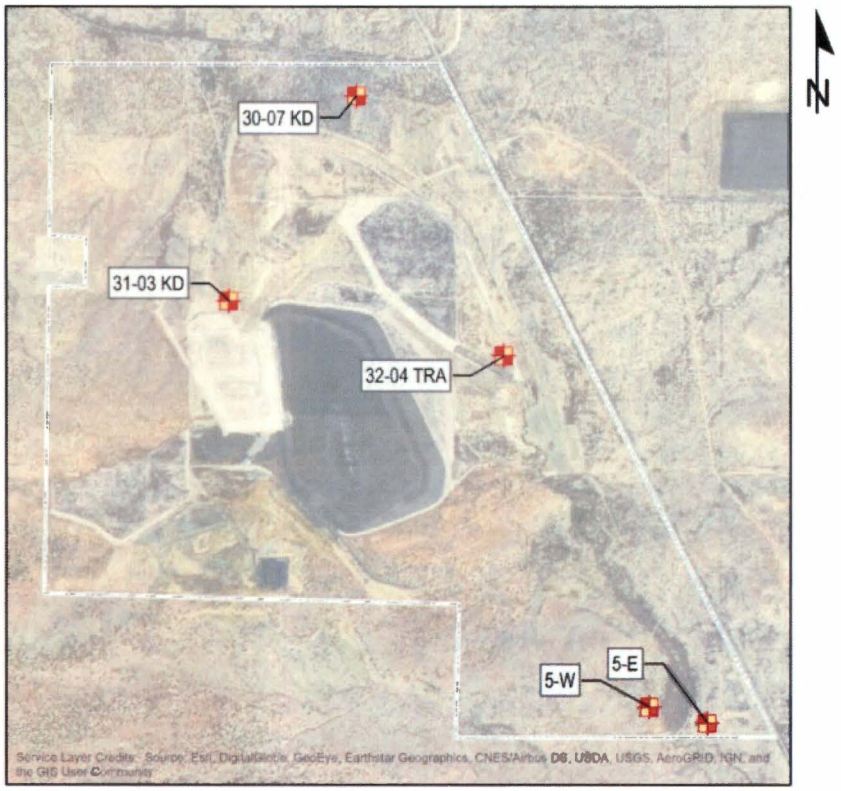
All measured radionuclide concentrations were below Site background values. Additionally, all radionuclide concentrations (inferred from gamma count rates) were at or below site background levels. Thus, ERG has concluded that workers are unlikely to be exposed to licensed material resulting in a dose above ten percent of applicable standards in 10 CFR 20 as a result of ACL drilling program activities.

I. Description of Work

On April 9, 2019, ERG performed vertical profiling at five different locations within the LTSM to quantify subsurface radioactivity and identify licensed radioactive constituents in the underlying soil. Vertical profiling was performed in support of Rio Algom Mining LLC's (RAML's) Alternate Concentration Limit (ACL) drilling program. Vertical profiling locations are presented in Figure 1. Vertical profiling at each location consisted of:

1) Prospective drill pad sites were located using a GPS unit with predetermined coordinates.
2) Prior to any measurements at each location, a 1-minute background shielded gamma count was taken on air, using a Ludlum 44-10 2x2 inch sodium iodide crystal paired to a Ludlum 3000 scaler ratemeter (Table 1).
3) Next, subsurface excavation began using a clean 2-inch diameter auger. Soil coil samples were collected at 6-inch intervals.
4) Soil was then placed into a stainless-steel bowl and homogenized before being transferred into a Marinelli beaker.
5) A 1-minute shielded gamma count was performed on each sample.
6) Soil was transferred into Ziploc bags and labeled for later identification.
7) Steps 3-6 were repeated until refusal was met.
8) Upon completion of excavation, a second 1-minute background shielded gamma count was obtained at each location.
9) Between each sample location the auger was cleaned using deionized water to prevent cross contamination between holes.

Upon completion of vertical profiling, selected soil samples (Table 2) were sent to GEL Laboratories for analysis by the methods described in Table 3. The laboratory results were used to build a predictive, statistical model between observed gamma count rate and soil concentrations of radionuclides.



ERG - ER
April 8, 2019

Figure 1 Map of characterized ACL drill pads

Table 1 Summary of radiation detecting equipment used for vertical profiling

Manufacturer	Model No.	Description	Serial No.
Ludlum	3000	Scaler/ratemeter	25016973
Ludlum	44-10	Detector	PR375295

Table 2 Summary of soil samples sent to GEL Laboratory

Sample ID	Note
05-E-3.0-3.5-040919	Location: 05-E, Depth: 3' - 3.5'
05-E-3.5-4.0-040919	Location: 05-E, Depth: 3.5' – 4'
05-W-0.5-1.0-040919	Location: 05-W, Depth: 0.5' – 1'
05-W-3.5-4.0-040919	Location: 05-W, Depth: 3.5' – 4'
05-W-4.5-5.0-040919	Location: 05-W, Depth: 4.5' – 5'
30-07-KD-0.0-0.5-040919	Location: 30-07-KD, Depth: 0.0' – 0.5'
32-04-TRA-2.5-3.0-040919	Location: 32-04-TRA, Depth: 2.5' – 3'
32-04-TRA-3.0-3.5-040919	Location: 32-04-TRA, Depth: 3' – 3.5'
32-04-TRA-3.5-4.0-040919	Location: 32-04-TRA, Depth: 3.5' – 4'
32-04-TRA-4.0-4.5-040919	Location: 32-04-TRA, Depth: 4' – 4.5'
32-04-TRA-4.5-5.0-040919	Location: 32-04-TRA, Depth: 4.5' – 5'
32-04-TRA-5.0-5.5-040919	Location: 32-04-TRA, Depth: 5' – 5.5'
32-04-TRA-5.5-6.0-040919	Location: 32-04-TRA, Depth: 5.5' – 6'
32-04-TRA-6.0-6.5-040919	Location: 32-04-TRA, Depth: 6' – 6.5'
32-04-TRA-6.5-7.0-040919	Location: 32-04-TRA, Depth: 6.5' – 7'

Table 3 Summary of laboratory methods

Analyte	Method Number	Analytic Method
Arsenic	3050B/6020B	ICP-MS
Barium	3050B/6020B	ICP-MS
Molybdenum	3050B/6020B	ICP-MS
Radium-226	DOE HASL 300	Gamma Spectroscopy
Selenium	3050B/6020B	ICP-MS
Thorium-230	DOE EML HASL-300	Gamma Spectroscopy
Uranium-238	DOE HASL 300	Gamma Spectroscopy
Vanadium	3050B/6020B	ICP-MS

Note: 3050B is acid digestion using nitric acid and hydrogen peroxide, 6020B refers to the analytic method used

II. Depth Profile Results

Depth profiles show that each location has low gamma count rates at all depths, with no single soil sample having a net shielded gamma count rate of more than 1,200 counts per minute (cpm). Net count rates of this magnitude indicate an absence of gamma emitting radionuclides in excess of background concentrations.

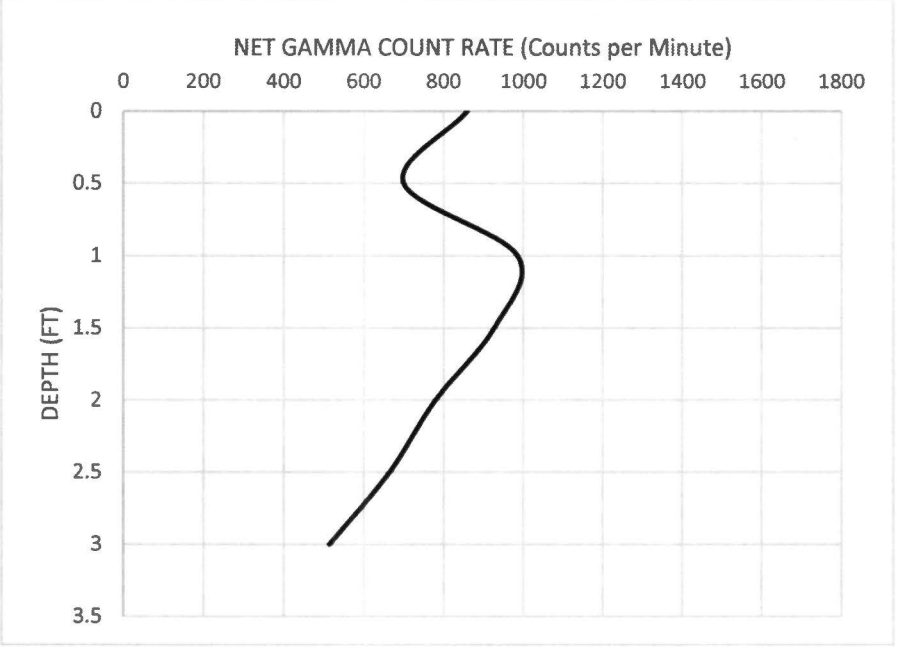


Figure 2 Vertical profile of gamma count rate at well pad 31-03 KD

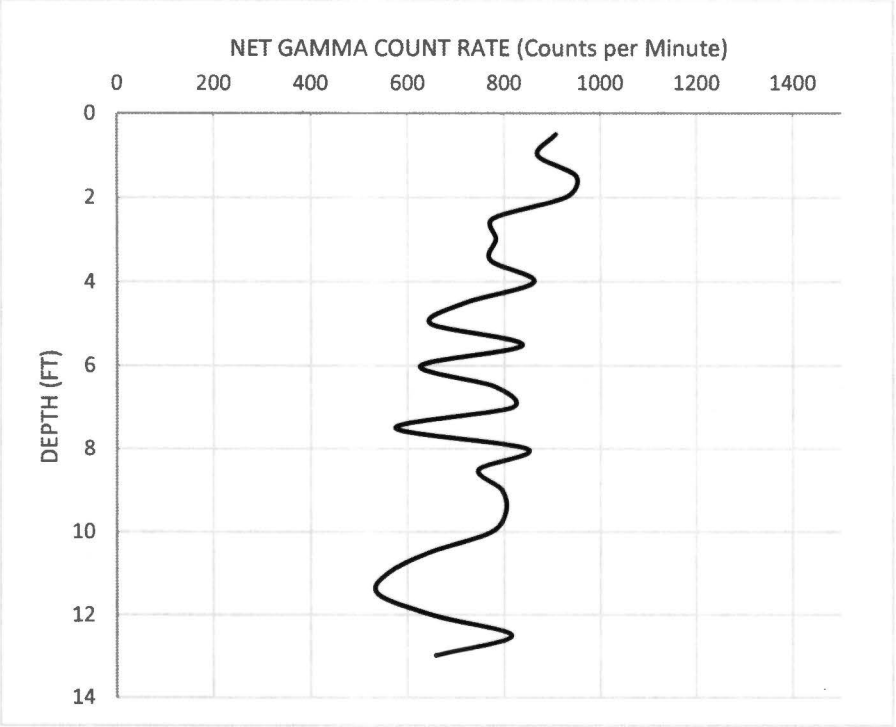


Figure 3 Vertical profile of gamma count rate at well pad 30-07 KD

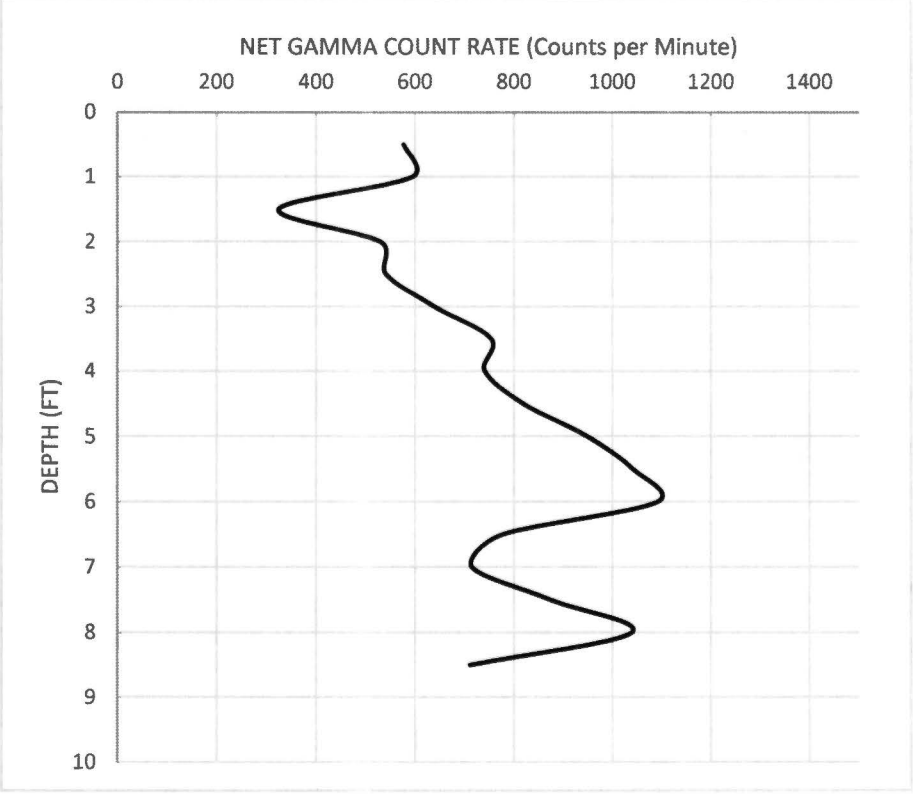


Figure 4 Vertical profile of gamma count rate at well pad 32-04 TRA

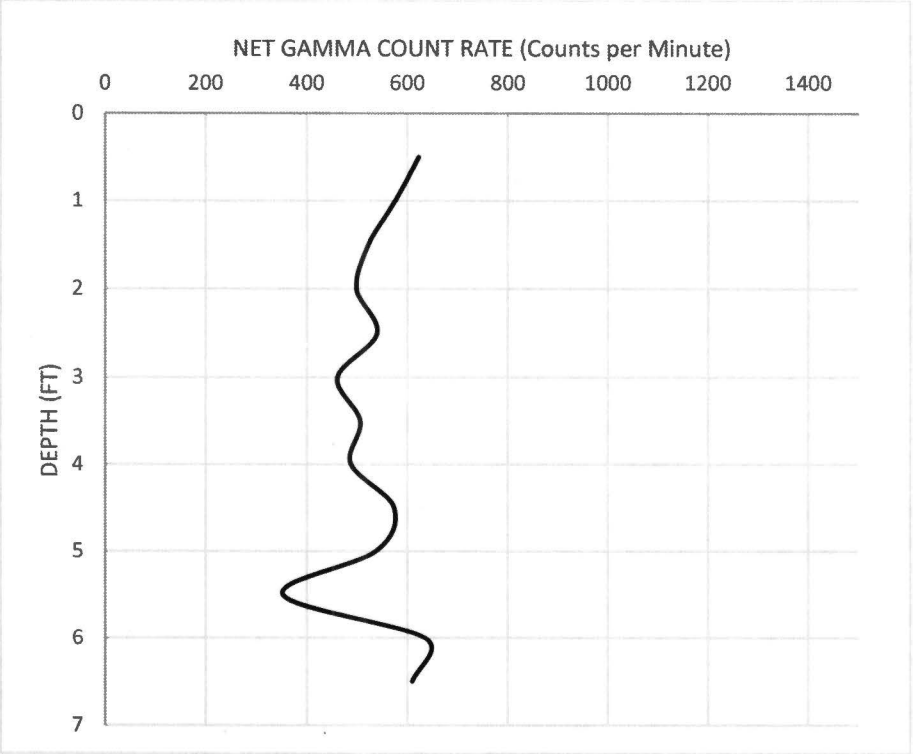


Figure 5 Vertical profile of gamma count rate at well pad 5-W

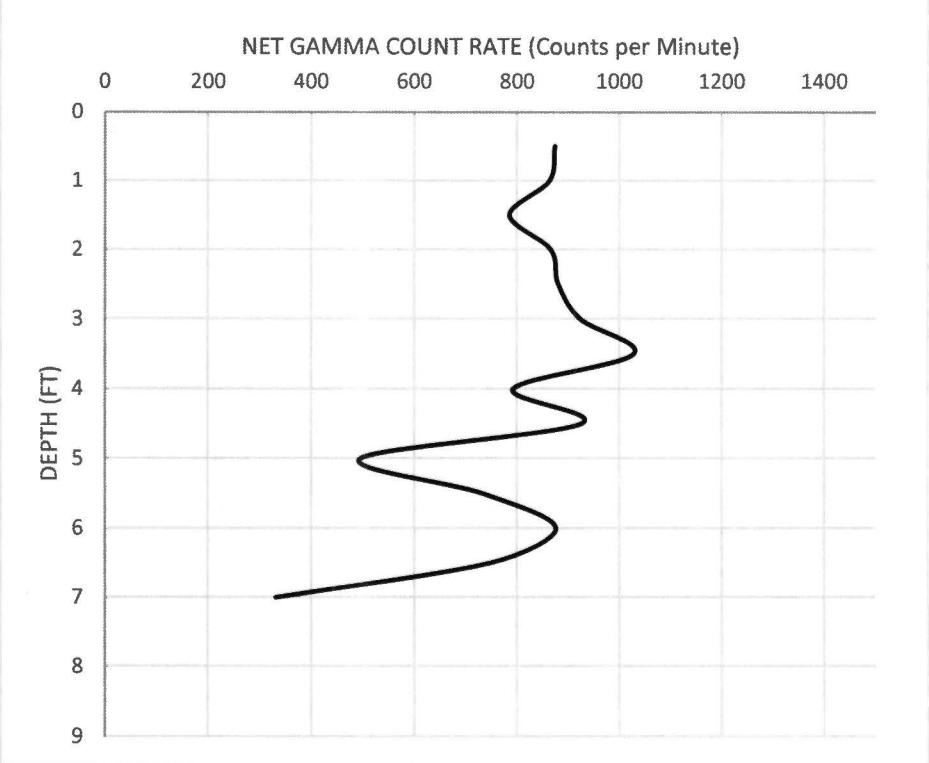


Figure 6 Vertical profile of gamma count rate at well pad 5-E

III. Analytic Results

Mean concentration of radionuclides found within soil samples fall below site background values defined in the Site Soil Decommissioning Plan (Komex, 2006). All individual results for radium-226 and thorium-230 are less than site background values. Six individual results (from 05-E, 32-04 TRA, and 30-07 KD) exceeded the mean site background concentration for uranium-238, with measured concentrations of uranium-238 between 2.3 to 3.27 pCi g^{-1}. The range of observed uranium-238 concentrations was within the range of uranium-238 background concentrations published by Komex (2006).

No site background concentrations are available for other heavy metals, so no comparison has been performed.

Table 4 Summary statistics for samples sent to lab

Analyte	Unit	n	Mean	Median	Std. Deviation	Site background[1]
Ra-226	pCi g^{-1}	15	0.958	0.982	0.401	1.95
Th-230	pCi g^{-1}	15	0.785	0.908	0.407	2.69
U-238	pCi g^{-1}	15	1.37	1.22	1.22	1.65
As	µg kg^{-1}	15	5311	5640	2162	None
Ba	µg kg^{-1}	15	108013	98500	34375	None
Mo	µg kg^{-1}	15	456	413	246	None
Se	µg kg^{-1}	15	1579	1540	776	None
V	µg kg^{-1}	15	22271	21300	9291	None

[1]Site backgrounds from Komex (2006).

IV. Correlation Analysis

The correlation between radium-226 and gamma count rate was variable, indicating that the gamma measurements made as part of the correlation study are most likely within the range of background. Based on the analysis provided, thorium-230 and radium-226 were determined to be in secular equilibrium.

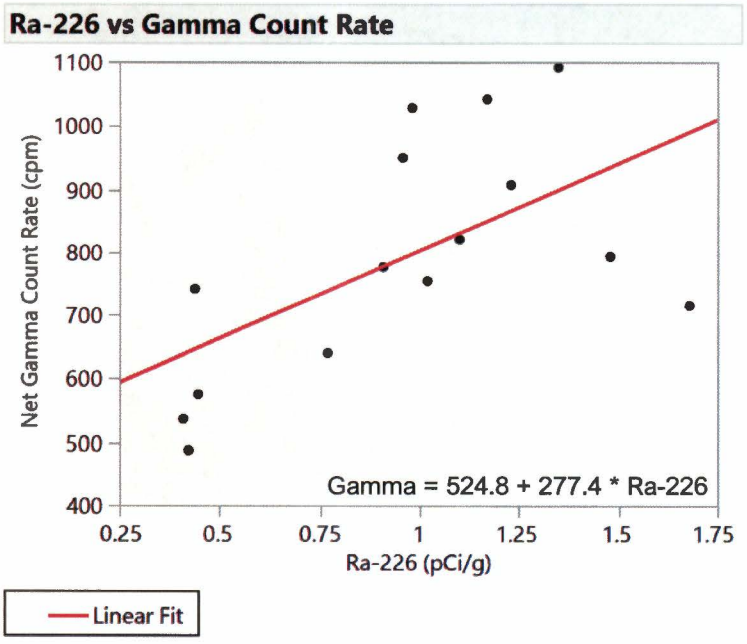


Figure 7 Correlation between static gamma count rate and laboratory reported concentration of radium-226.
Note: Shaded bands depict the regression 95% prediction intervals.

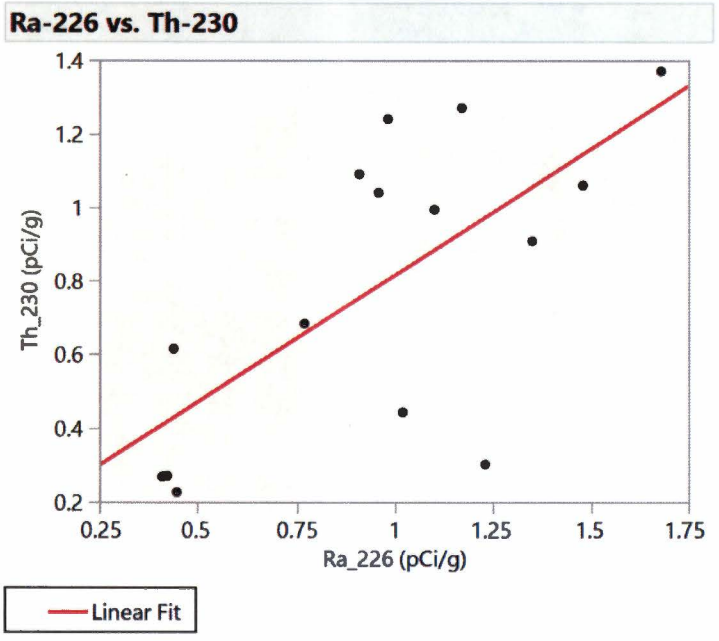


Figure 8 Correlation between laboratory reported concentration of radium-226 and thorium-230.
Note: Shaded bands depict the regression 95% prediction intervals.

Table 5 Inferred maximum concentration of radium-226 (using the regression mean line) for each vertical profile location

Location	Depth of Max Reading	Max Gamma Count Rate	Inferred radium-226
	ft	cpm	pCi/g
31-03 KD	1-1.5	984.5	1.66
30-07 KD	1-1.5	950.5	1.53
32-04 TRA	5.5-6	1091	2.04
5-W	5.5-6	635.5	0.399
5-E	3-3.5	1028	1.81

V. Conclusion

All measured radionuclide concentrations were below Site background values. Additionally, all radionuclide concentrations (inferred from gamma count rates) were at or below site background levels. Thus, ERG has concluded that workers are unlikely to be exposed to licensed material resulting in a dose above ten percent of applicable standards in 10 CFR 20 as a result of ACL drilling program activities.

References

EPA, 1996. "Method 3050B Acid Digestion of Sediments, Sludges, and Soils". December 1996

EPA, 2014. "Method 6020B Inductively Coupled Plasma – Mass Spectrometry". July 2014

Komex, 2006. Komex Environmental and HG Engineering Ltd, 2006. Soil Decommissioning Plan: Rio Algom Mining LLC, Ambrosia Lake Facility, Grants, New Mexico. May 1, 2006.

Appendix A – Vertical Profiling Raw Data

Table 6 Vertical profile data for 31-03 KD

Background 1	681	cpm
Background 2	714	cpm
Mean Background	**697.5**	**cpm**

Top Depth	Bottom Depth	Gross Gamma	Net Gamma	Observations
ft	ft	cpm	cpm	
0	0.5	1556	859	Unsaturated Silty Clay
0.5	1	1397	670	Unsaturated Silty Loam
1	1.5	1682	985	Silty Loam
1.5	2	1624	927	Silty Loam/Cobbles
2	2.5	1477	780	Silty Loam/Cobbles
2.5	3	1362	665	Silty Loam/Cobbles
3	3.5	1211	514	Beaker 50% Full. Bedrock Refusal

Table 7 Vertical profile data for 30-07 KD

Background 1	1042	cpm
Background 2	1059	cpm
Mean Background	**1050.5**	**cpm**

Top Depth	Bottom Depth	Gross Gamma	Net Gamma	Observations
ft	ft	cpm	cpm	
0	0.5	1958	908	Dry and Silty
0.5	1	1920	870	Silty Clay
1	1.5	2001	951	Silty Clay
1.5	2	1978	928	Silty Loam. Damp
2	2.5	1827	777	Silty Loam. Damp
2.5	3	1833	783	Silty Loam. Damp

3	3.5	1822	772	Silty Loam , Unsaturated
3.5	4	1912	862	Silty Loam , Unsaturated
4	4.5	1769	719	Silty Loam , Unsaturated
4.5	5	1698	648	Silty Loam , Unsaturated
5	5.5	1888	838	Sandy Loam, Damp
5.5	6	1676	626	Sandy Loam, Damp
6	6.5	1830	780	Sandy Loam, Damp
6.5	7	1867	817	Sandy Loam, Damp
7	7.5	1625	575	Sandy Loam, Damp
7.5	8	1898	848	Sandy Loam, Unsaturated
8	8.5	1797	747	Sandy Loam, Unsaturated
8.5	9	1845	795	Sandy Loam, Unsaturated
9	9.5	1854	804	Sandy Loam, Unsaturated
9.5	10	1823	773	Sandy Loam, Unsaturated
10	10.5	1695	645	Sandy Loam, Unsaturated
10.5	11	1610	560	Sandy Loam, Unsaturated
11	11.5	1589	539	Sandy Loam, Unsaturated
11.5	12	1703	653	Sandy Loam, Unsaturated
12	12.5	1866	816	Sandy Loam, Unsaturated
12.5	13	1710	660	Sandy Loam, Unsaturated

Table 8 Vertical profile data for 32-04 TRA

Background 1	939	cpm
Background 2	917	cpm
Mean Background	**928**	**cpm**

Top Depth	Bottom Depth	Gross Gamma	Net Gamma	Observations
ft	ft	cpm	cpm	
0	0.5	1505	577	Clay (25%) Silty Loam (75%), Unsaturated
0.5	1	1522	594	Clay (25%) Silty Loam (75%), Unsaturated
1	1.5	1253	325	Sandy Loam, Unsaturated
1.5	2	1458	530	Sandy Loam, Unsaturated
2	2.5	1469	541	Sandy Loam, Unsaturated
2.5	3	1568	640	High Clay Content, Damp
3	3.5	1682	754	High Clay Content, Damp
3.5	4	1669	741	High Clay Content, Damp
4	4.5	1748	820	High Clay Content, Damp
4.5	5	1878	950	High Clay Content, Damp
5	5.5	1970	1042	High Clay Content, Damp
5.5	6	2019	1091	High Clay Content, Damp
6	6.5	1704	776	High Clay Content, Damp
6.5	7	1643	715	High Clay Content, Damp
7	7.5	1803	875	High Clay Content, Damp
7.5	8	1967	1039	High Clay Content, Damp
8	8.5	1639	711	High Clay Content, Damp

Table 9 Vertical profile data for 5-W

Background 1	743	cpm
Background 2	780	cpm
Mean Background	**761.5**	**cpm**

Top Depth	Bottom Depth	Gross Gamma	Net Gamma	Observations
ft	ft	cpm	cpm	
0	0.5	1384	623	Sandy Loam. Unsaturated
0.5	1	1337	576	Sandy Loam. Unsaturated
1	1.5	1284	523	Sandy Loam. Unsaturated
1.5	2	1260	499	Sandy Loam. Unsaturated
2	2.5	1301	540	Sandy Loam/ Cobbles
2.5	3	1222	461	Sandy Loam/ Cobbles
3	3.5	1268	507	Sandy Loam/ Cobbles
3.5	4	1249	488	Sandy Loam/ Cobbles
4	4.5	1335	574	Sandy Loam/ Cobbles
4.5	5	1298	537	Sandy Loam/ Cobbles
5	5.5	1114	353	Material too fine to be collected by auger. Beaker 75% Full
5.5	6	1397	636	Sandy Loam/ Cobbles
6	6.5	1371	610	Bedrock Refusal

Table 10 Vertical profile data for 5-E

Background 1	904	cpm
Background 2	977	cpm
Mean Background	**940.5**	**cpm**

Top Depth	Bottom Depth	Gross Gamma	Net Gamma	Observations
ft	ft	cpm	cpm	
0	0.5	1815	875	Sandy Clay. Unsaturated
0.5	1	1804	864	Sandy Clay. Unsaturated
1	1.5	1726	786	Sand Unsaturated
1.5	2	1807	867	Sand Unsaturated
2	2.5	1821	881	Sand/Cobbles
2.5	3	1864	924	Sand Unsaturated
3	3.5	1969	1029	Sand Unsaturated
3.5	4	1733	793	Material too fine to be collected by auger. Beaker was only 75% full
4	4.5	1866	926	Sand
4.5	5	1436	496	Material too fine to be collected by auger. Beaker 60% Full
5	5.5	1674	734	Sand Unsaturated
5.5	6	1817	877	Sand. Beaker only 50% Full
6	6.5	1688	748	Sand. Beaker only 75% Full
6.5	7	1272	332	Material too fine to be collected by auger. Beaker only 40% Full

Appendix B – Laboratory Analytical Results

Table 11 Laboratory analytical results

Sample ID	Parameter	Result	Uncertainty	Units	Flag	MDL
05-E-3.0-3.5-040919	Arsenic	5640		µg/kg		341
05-E-3.0-3.5-040919	Barium	98500		µg/kg	*	101
05-E-3.0-3.5-040919	Molybdenum	350		µg/kg	N	80.8
05-E-3.0-3.5-040919	Selenium	1540		µg/kg		364
05-E-3.0-3.5-040919	Vanadium	21300		µg/kg		303
05-E-3.0-3.5-040919	Radium-226	0.982	0.227	pCi/g		0.139
05-E-3.0-3.5-040919	Thorium-230	1.24	0.717	pCi/g		0.572
05-E-3.0-3.5-040919	Uranium-238	2.79	3.73	pCi/g	U	4.01
05-E-3.5-4.0-040919	Arsenic	6530		µg/kg		366
05-E-3.5-4.0-040919	Barium	129000		µg/kg	*	108
05-E-3.5-4.0-040919	Molybdenum	352		µg/kg	N	86.7
05-E-3.5-4.0-040919	Selenium	1960		µg/kg		390
05-E-3.5-4.0-040919	Vanadium	26000		µg/kg		325
05-E-3.5-4.0-040919	Radium-226	1.48	0.226	pCi/g		0.101
05-E-3.5-4.0-040919	Thorium-230	1.06	0.416	pCi/g		0.221
05-E-3.5-4.0-040919	Uranium-238	0.00	1.13	pCi/g	UI	0.782
05-W-0.5-1.0-040919	Arsenic	2650		µg/kg		353
05-W-0.5-1.0-040919	Barium	84000		µg/kg	*	104
05-W-0.5-1.0-040919	Molybdenum	172		µg/kg	BN	83.6
05-W-0.5-1.0-040919	Selenium	778		µg/kg	B	376
05-W-0.5-1.0-040919	Vanadium	13700		µg/kg		313
05-W-0.5-1.0-040919	Radium-226	0.447	0.129	pCi/g		0.107
05-W-0.5-1.0-040919	Thorium-230	0.226	0.215	pCi/g	U	0.227
05-W-0.5-1.0-040919	Uranium-238	1.34	1.99	pCi/g	U	1.45
05-W-3.5-4.0-040919	Arsenic	2230		µg/kg		347
05-W-3.5-4.0-040919	Barium	81600		µg/kg	*	103
05-W-3.5-4.0-040919	Molybdenum	126		µg/kg	BN	82.2
05-W-3.5-4.0-040919	Selenium	478		µg/kg	B	370
05-W-3.5-4.0-040919	Vanadium	11300		µg/kg		308
05-W-3.5-4.0-040919	Radium-226	0.423	0.159	pCi/g		0.106
05-W-3.5-4.0-040919	Thorium-230	0.270	0.238	pCi/g	U	0.279
05-W-3.5-4.0-040919	Uranium-238	0.00	2.59	pCi/g	UI	1.70
05-W-4.5-5.0-040919	Arsenic	2340		µg/kg		334
05-W-4.5-5.0-040919	Barium	121000		µg/kg	*	98.8
05-W-4.5-5.0-040919	Molybdenum	114		µg/kg	BN	79.0
05-W-4.5-5.0-040919	Selenium	381		µg/kg	B	356
05-W-4.5-5.0-040919	Vanadium	9860		µg/kg		296
05-W-4.5-5.0-040919	Radium-226	0.410	0.152	pCi/g		0.104
05-W-4.5-5.0-040919	Thorium-230	0.268	0.203	pCi/g		0.198
05-W-4.5-5.0-040919	Uranium-238	0.574	0.968	pCi/g	U	2.10
30-07-KD-0.0-0.5-040919	Arsenic	6140		µg/kg		366
30-07-KD-0.0-0.5-040919	Barium	120000		µg/kg	*	108
30-07-KD-0.0-0.5-040919	Molybdenum	683		µg/kg	N	86.6
30-07-KD-0.0-0.5-040919	Selenium	1810		µg/kg		390
30-07-KD-0.0-0.5-040919	Vanadium	22200		µg/kg		325

Sample ID	Parameter	Result	Uncertainty	Units	Flag	MDL
30-07-KD-0.0-0.5-040919	Radium-226	1.23	0.166	pCi/g		0.0958
30-07-KD-0.0-0.5-040919	Thorium-230	0.301	0.396	pCi/g	U	0.638
30-07-KD-0.0-0.5-040919	Uranium-238	2.30	2.19	pCi/g		1.83
32-04-TRA-2.5-3.0-040919	Arsenic	3500		µg/kg		355
32-04-TRA-2.5-3.0-040919	Barium	64100		µg/kg	*	105
32-04-TRA-2.5-3.0-040919	Molybdenum	772		µg/kg	N	84.1
32-04-TRA-2.5-3.0-040919	Selenium	1070		µg/kg		378
32-04-TRA-2.5-3.0-040919	Vanadium	13500		µg/kg		315
32-04-TRA-2.5-3.0-040919	Radium-226	0.770	0.140	pCi/g		0.0786
32-04-TRA-2.5-3.0-040919	Thorium-230	0.681	0.324	pCi/g		0.114
32-04-TRA-2.5-3.0-040919	Uranium-238	2.38	0.785	pCi/g		0.762
32-04-TRA-3.0-3.5-040919	Arsenic	4240		µg/kg		400
32-04-TRA-3.0-3.5-040919	Barium	82600		µg/kg	*	118
32-04-TRA-3.0-3.5-040919	Molybdenum	952		µg/kg	N	94.6
32-04-TRA-3.0-3.5-040919	Selenium	1250		µg/kg		426
32-04-TRA-3.0-3.5-040919	Vanadium	16000		µg/kg		355
32-04-TRA-3.0-3.5-040919	Radium-226	1.02	0.207	pCi/g		0.144
32-04-TRA-3.0-3.5-040919	Thorium-230	0.442	0.538	pCi/g	U	0.721
32-04-TRA-3.0-3.5-040919	Uranium-238	2.74	1.56	pCi/g		1.08
32-04-TRA-3.5-4.0-040919	Arsenic	3340		µg/kg		354
32-04-TRA-3.5-4.0-040919	Barium	64800		µg/kg	*	105
32-04-TRA-3.5-4.0-040919	Molybdenum	791		µg/kg	N	83.7
32-04-TRA-3.5-4.0-040919	Selenium	832		µg/kg	B	377
32-04-TRA-3.5-4.0-040919	Vanadium	15600		µg/kg		314
32-04-TRA-3.5-4.0-040919	Radium-226	0.439	0.123	pCi/g		0.0832
32-04-TRA-3.5-4.0-040919	Thorium-230	0.613	0.350	pCi/g		0.331
32-04-TRA-3.5-4.0-040919	Uranium-238	1.22	1.90	pCi/g	U	1.83
32-04-TRA-4.0-4.5-040919	Arsenic	6320		µg/kg		402
32-04-TRA-4.0-4.5-040919	Barium	112000		µg/kg	*	119
32-04-TRA-4.0-4.5-040919	Molybdenum	427		µg/kg	N	95.1
32-04-TRA-4.0-4.5-040919	Selenium	1900		µg/kg		428
32-04-TRA-4.0-4.5-040919	Vanadium	25400		µg/kg		357
32-04-TRA-4.0-4.5-040919	Radium-226	1.10	0.211	pCi/g		0.128
32-04-TRA-4.0-4.5-040919	Thorium-230	0.994	0.430	pCi/g		0.272
32-04-TRA-4.0-4.5-040919	Uranium-238	0.00	3.34	pCi/g	UI	2.74
32-04-TRA-4.5-5.0-040919	Arsenic	5010		µg/kg		415
32-04-TRA-4.5-5.0-040919	Barium	89200		µg/kg	*	123
32-04-TRA-4.5-5.0-040919	Molybdenum	448		µg/kg	N	98.2
32-04-TRA-4.5-5.0-040919	Selenium	1520		µg/kg		442
32-04-TRA-4.5-5.0-040919	Vanadium	20000		µg/kg		368
32-04-TRA-4.5-5.0-040919	Radium-226	0.958	0.190	pCi/g		0.140
32-04-TRA-4.5-5.0-040919	Thorium-230	1.04	0.393	pCi/g		0.236
32-04-TRA-4.5-5.0-040919	Uranium-238	0.00	3.89	pCi/g	UI	2.86
32-04-TRA-5.0-5.5-040919	Arsenic	7650		µg/kg		389
32-04-TRA-5.0-5.5-040919	Barium	156000		µg/kg	*	115
32-04-TRA-5.0-5.5-040919	Molybdenum	395		µg/kg	N	92.2
32-04-TRA-5.0-5.5-040919	Selenium	2410		µg/kg		415

Sample ID	Parameter	Result	Uncertainty	Units	Flag	MDL
32-04-TRA-5.0-5.5-040919	Vanadium	34800		µg/kg		346
32-04-TRA-5.0-5.5-040919	Radium-226	1.17	0.212	pCi/g		0.146
32-04-TRA-5.0-5.5-040919	Thorium-230	1.27	0.407	pCi/g		0.157
32-04-TRA-5.0-5.5-040919	Uranium-238	1.06	2.05	pCi/g	U	1.80
32-04-TRA-5.5-6.0-040919	Arsenic	7930		µg/kg		402
32-04-TRA-5.5-6.0-040919	Barium	94400		µg/kg	*	119
32-04-TRA-5.5-6.0-040919	Molybdenum	413		µg/kg	N	95.2
32-04-TRA-5.5-6.0-040919	Selenium	2500		µg/kg		428
32-04-TRA-5.5-6.0-040919	Vanadium	33100		µg/kg		357
32-04-TRA-5.5-6.0-040919	Radium-226	1.35	0.207	pCi/g		0.165
32-04-TRA-5.5-6.0-040919	Thorium-230	0.908	0.492	pCi/g		0.398
32-04-TRA-5.5-6.0-040919	Uranium-238	0.208	2.38	pCi/g	U	4.47
32-04-TRA-6.0-6.5-040919	Arsenic	7460		µg/kg		404
32-04-TRA-6.0-6.5-040919	Barium	135000		µg/kg	*	120
32-04-TRA-6.0-6.5-040919	Molybdenum	405		µg/kg	N	95.7
32-04-TRA-6.0-6.5-040919	Selenium	2330		µg/kg		431
32-04-TRA-6.0-6.5-040919	Vanadium	31300		µg/kg		359
32-04-TRA-6.0-6.5-040919	Radium-226	0.909	0.246	pCi/g		0.154
32-04-TRA-6.0-6.5-040919	Thorium-230	1.09	0.380	pCi/g		0.181
32-04-TRA-6.0-6.5-040919	Uranium-238	3.27	3.86	pCi/g	U	4.15
32-04-TRA-6.5-7.0-040919	Arsenic	8690		µg/kg		403
32-04-TRA-6.5-7.0-040919	Barium	188000		µg/kg	*	119
32-04-TRA-6.5-7.0-040919	Molybdenum	438		µg/kg	N	95.3
32-04-TRA-6.5-7.0-040919	Selenium	2920		µg/kg		429
32-04-TRA-6.5-7.0-040919	Vanadium	40000		µg/kg		357
32-04-TRA-6.5-7.0-040919	Radium-226	1.68	0.260	pCi/g		0.151
32-04-TRA-6.5-7.0-040919	Thorium-230	1.37	0.430	pCi/g		0.220
32-04-TRA-6.5-7.0-040919	Uranium-238	2.68	3.08	pCi/g	U	2.94

Note: U flag – Analyte was analyzed for, but not detected above the MDL, MDA, MDC, or LOD
UI flag – Gamma Spectroscopy—uncertain identification
* flag – a quality control analyte recovery is outside of specified acceptance criteria
B flag – either presence of analyte detected in associated blank, or MDL/IDL < sample value <PQL
N flag – Metals – the Matrix spike sample recovery is not within specified control limits