

**Pit 1 Pile Investigation
St. Anthony Mine Site
Seboyeta, New Mexico**

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1.0 Introduction and Background

This report provides the results of the Pit 1 piles radiologic characterization (Pit 1 Investigation) that was conducted at the St. Anthony Mine Site (Site) near Seboyeta, New Mexico. The purpose of this investigation was to estimate the Ra-226 concentrations of the piles in Pit 1. The characterization was performed by collecting soil samples from test pits, and conducting onsite ex-situ gamma radiation soil screening and vendor laboratory analysis on the samples. Field activities began on November 4, 2019 and were completed on November 6, 2019. The methods and procedures used were consistent with Section 4 of the 2018 Supplemental Investigations Work Plan (2018 Work Plan; Stantec, 2019). Test pit names and locations are shown in Figure 1.

Mine site features were characterized in 2007, as described in the *Materials Characterization Report, Saint Anthony Mine Site* (MWH, 2007). The remaining areas of the Site were characterized during the 2018 Supplemental Radiologic Characterization (AVM, 2018). The following sections describe the methods and procedures that were used and the results of the Pit 1 Investigation.

2.0 Previous Characterizations

As noted above, only the mine site features were radiologically characterized during the 2007 Materials Characterization. The features defined in the 2007 Materials Characterization included the Background Area, Borrow Sources, Top Soil Stockpiles, Non-Economic Materials Storage Piles, and the Western Shaft Area. Gamma exposure rate surveys and soil sampling were conducted during the 2007 Material Characterization. The 2007 characterization included gamma exposure rate surveys in Pit 1 with gamma exposure rates measured at one meter above the ground surface with shielded and unshielded meters. Measurements were also collected with a shielded meter at ground surface contact. Areas between the site features were not radiologically characterized in 2007 and the lateral extent of radiologic contamination was still unknown. Background levels were established during this phase of work at a Ra-226 value of 1.6 pCi/g for the Site.

The 2018 Supplemental Radiological Characterization was performed to delineate the radiologic contamination boundary based upon an Investigation Level (IL) of 5.0 pCi/g plus 1.6 pCi/g background level, and to characterize the Site by performing radiological surveys and collecting soil samples in the areas between the mine features. No sampling of the piles in Pit 1 was conducted during the previous Site radiologic characterizations.

3.0 Objective of the Pit 1 Pile Investigation

The Site is a former uranium mine, therefore the surface and subsurface soil within the piles are expected to be impacted by radionuclides associated with the uranium decay series, with Ra-226 being the primary Constituent of Concern (COC). The objective of the Pit 1 Investigation was to estimate the concentration of Ra-226 in the Pit 1 Piles.

4.0 Field Investigation

Field activities for the Pit 1 Investigation were conducted consistent with the methods and procedures specified in the 2018 Work Plan. The field investigation activities included field-locating test pit locations, excavation of test pits, soil sampling and transport of the soil samples to the onsite ex-situ soil screening station for analysis. Provisional test pit locations were selected prior to conducting the field activities using satellite imagery. As each provisional test pit was field-located using a sub-meter accurate Differential Global Positioning System (DGPS), they were relocated as needed to ensure both horizontal and vertical characterization of each pile to the extent practical. Cuts large enough to safely excavate test pits were made on the sides of large piles midway from the top and bottom. Each test pit consisted of three or four depth samples, depending on professional judgement and test pit excavation refusal. Table 1 shows test pit sample data and radiological data. A track excavator was used to excavate a trench at each test pit location for subsurface soil sample collection. At each depth, a soil sample was collected in a gallon Ziploc bag. Each sample was labeled based on the test pit location and depth of sample from the test pit surface. As an example, "TP-03-06" designates a sample from Test Pit 03 that is six feet below the surface prior to excavation. Any large rocks or debris were omitted from the sample. Upon completion of each test pit, the samples were then transported to the onsite ex-situ soil screening station located in a low radiation exposure area to minimize gamma radiation influence on the sample counts. The test pit excavation geotechnical logs are included in Appendix A. Prior to leaving any test pit location, the test pit was backfilled, leveled and marked with labeled pin flags. Each test pit location ID and corresponding coordinates were logged using a DGPS and are listed in Table 1 and test pit locations are shown in Figure 1.

4.1 Ex-Situ Gamma Radiation Soil Screening

The ex-situ gamma radiation soil screening was conducted in accordance with AVM SOP-4, included in the 2018 Work Plan, and provides a real-time estimate of Ra-226 concentrations in soil samples. This method is more reliable than the in-situ direct gamma surveys for real-time Ra-226 assessment in soils. The on-site ex-situ soil screening method consists of selectively measuring the 609 KeV region gamma radiations of Bi-214, a decay product of Ra-226. A single channel analyzer (Ludlum L2221) integrated with a Ludlum 44-20 3x3 NaI scintillation detector was used to measure the 609 keV energy peak region of Bi-214. The soil sample was placed around the plastic lined detector in a heavily shielded counting chamber. The heavily shielded counting chamber lowers the system background counts, thus improving the system's minimum detectable concentration (MDC). A 50 pCi/g reference soil was used for soil screening calibration checks. The test pit soil screening data is summarized in Table 1.

A total of 71 soil samples from 19 test pit locations were collected and analyzed by ex-situ soil screening. The Field Soil Sample Gamma Radiation Screening Forms completed during the ex-situ soil screening are included in Appendix B. One sample from each test pit was selected to be sent to the offsite vender laboratory, ALS, Inc. in Fort Collins, CO (ALS). Based on the ex-situ scanning concentration of the samples in the test pit, one sample which represented the average or slightly higher concentration of the test pit was selected for lab analysis. Additionally, two field QA/QC duplicate samples were also sent to ALS. These soil

samples were analyzed for Ra-226 using EPA Method 901.1 (modified for soil matrix) for confirmation of the onsite soil screening results, and for uranium using EPA Method SW3050B/6020.

5.0 Soil Sample Results

The sample chain of custody and laboratory results reports are included in Appendix C. The test pit soil sample ex-situ gamma radiation field soil screening results and the vendor laboratory results are summarized in Table 1. The ex-situ gamma radiation field soil screening results for Ra-226 conform with the vendor laboratory Ra-226 results. Ra-226 concentrations in the individual soil samples from the piles range from 7.5 pCi/g to 125.5 pCi/g. As shown in Table 2, the average Ra-226 concentration in individual test pits range from 13.7 pCi/g to 103.5 pCi/g, and the average Ra-226 concentration in the piles range from 25.0 pCi/g to 77.2 pCi/g. Uranium concentrations in the individual samples sent to the vendor laboratory from the test pits ranged from 19 mg/Kg to 130 mg/Kg, as shown in Table 1.

6.0 Quality Assurance and Quality Control Measures

Quality Assurance/Quality Control (QA/QC) measures as specified in the 2018 Work Plan were also implemented during the Pit 1 Investigation to ensure that the data is of acceptable quality. All radiologic survey instruments, including personnel and vehicle contamination friskers, were calibrated as specified in AVM SOP-1 which is included in the 2018 Work Plan. Additionally, operational function checks were performed on all radiologic instruments daily prior to use. The calibration, correlation and function check documents are included in Appendix D. During this characterization, no instruments were found to be out of calibration or inoperable as indicated by the daily operational function checks. A calibration/correlation of the ex-situ soil screening system was performed prior to mobilizing in the field using 25 pCi/g, 50 pCi/g, and 100 pCi/g reference soils. Daily operational function checks were performed on the ex-situ soil screening system prior to daily use. Based on the highest system background (blank) measurements from daily operational function checks and efficiency (pCi/g/cpm), the highest Ra-226 MDC for the screening system calculated was less than 0.8 pCi/g, significantly less than the expected concentrations in the test pit samples. The MDCs during the investigation met the QA objectives.

The QA/QC measures also included field QA/QC duplicate soil sampling at a frequency of 10% of the soil samples collected for laboratory analysis. As discussed above, field QA/QC duplicate soil samples were collected and sent to the laboratory for analysis, and the QA/QC duplicate results are included in the same tables with the original samples and are identified with a -D at the end of the sample name.

7.0 References

AVM, 2018. *Supplemental Radiologic Characterization, St. Anthony Mine Site*. August 13.

MWH, 2007. *Materials Characterization Report: Saint Anthony Mine Site*. October 26.

Stantec, 2018. *St. Anthony Supplemental Investigations Work Plan*. February 23.

Tables

Table 1
St. Anthony Mine Site
Pit 1 Pile Investigation Soil Sample Results Summary

Test Pit Sample Information							Field Soil Gamma Screening Data			Laboratory Data				Laboratory Data
Test Pit ID	Sample ID	Sample Date	Sample Time	Northing NAD83 NM West (feet)	Easting NAD83 NM West (feet)	Test Pit Elevation (feet)	Sample CPM (net avg)	Comments	Estimated Ra-226 pCi/g	Sample Sent to Lab	Ra-226 pCi/g	Error Estimate pCi/g	MDC pCi/g	Uranium mg/Kg
TP-01	TP-01-01	11/5/19	1400	1,516,031.0	2,880,739.3	6,011.5	6807	Field QA/QC Dup	116.4	Y	120.0	14.0	1.0	100
	TP-01-01-D	11/5/19								Y	117.0	14.0	2.0	110
	TP-01-03	11/5/19	1415				4531		76.8	N	-	-	-	-
	TP-01-06	11/5/19	1420				5592		95.3	N	-	-	-	-
	TP-01-08	11/5/19	1430				7332		125.5	N	-	-	-	-
TP-02	TP-02-02	11/5/19	1440	1,516,031.6	2,880,915.5	6,003.8	2480		41.1	N	-	-	-	-
	TP-02-03	11/5/19	1445				3646		61.4	N	-	-	-	-
	TP-02-06	11/5/19	1450				5775		98.5	N	-	-	-	-
	TP-02-08	11/5/19	1500				4167		70.5	Y	68.2	8.2	1.5	83
TP-03	TP-03-01	11/6/19	805	1,515,881.7	2,880,927.0	5,987.4	3369		56.6	N	-	-	-	-
	TP-03-03	11/6/19	810				3953		66.8	N	-	-	-	-
	TP-03-06	11/6/19	820				3827		64.6	Y	65.6	7.8	1.0	93
	TP-03-08	11/6/19	825				2622		43.6	N	-	-	-	-
TP-04	TP-04-01	11/5/19	1510	1,516,000.6	2,880,983.4	5,987.3	3041		50.9	N	-	-	-	-
	TP-04-03	11/5/19	1515				5214		88.7	Y	94.0	11.0	2.0	130
	TP-04-06	11/5/19	1520				4623		78.4	N	-	-	-	-
	TP-04-07	11/5/19	1530				4078		68.9	N	-	-	-	-
TP-05	TP-05-01	11/6/19	830	1,515,828.9	2,880,972.0	5,974.8	5273		89.7	Y	94.0	11.0	1.0	97
	TP-05-05	11/6/19	840				4727		80.2	N	-	-	-	-
TP-06	TP-06-01	11/5/19	1105	1,514,967.3	2,881,320.8	5,923.2	1562		25.1	N	-	-	-	-
	TP-06-03	11/5/19	1115				2539		42.1	N	-	-	-	-
	TP-06-06	11/5/19	1120				1141		17.8	N	-	-	-	-
	TP-06-07	11/5/19	1130				1937		31.7	Y	34.7	4.2	0.8	50
TP-07	TP-07-03	11/5/19	1005	1,514,972.3	2,881,538.1	5,925.8	1280		20.2	N	-	-	-	-
	TP-07-06	11/5/19	1010				1686		27.3	N	-	-	-	-
	TP-07-09	11/5/19	1020				1486		23.8	Y	23.4	2.9	0.9	45

Table 1 (Continued)
St. Anthony Mine Site
Pit 1 Pile Investigation Soil Sample Results Summary

Test Pit Sample Information							Field Soil Gamma Screening Data			Laboratory Data				Laboratory Data	
Test Pit ID	Sample ID	Sample Date	Sample Time	Northing NAD83 NM West (feet)	Easting NAD83 NM West (feet)	Test Pit Elevation (feet)	Sample CPM (net avg)	Comments	Estimated Ra-226 pCi/g	Sample Sent to Lab	Ra-226 pCi/g	Error Estimate pCi/g	MDC pCi/g	Uranium mg/Kg	
TP-08	TP-08-01	11/5/19	1040	1,514,859.3	2,881,358.3	5,930.9	550		7.5	N	-	-	-	-	
	TP-08-03	11/5/19	1045				1228		19.3	N	-	-	-	-	-
	TP-08-06	11/5/19	1050				686		9.9	N	-	-	-	-	-
	TP-08-08	11/5/19	1055				1155		18.1	Y	18.4	2.3	0.8	19	
TP-09	TP-09-01	11/5/19	930	1,514,918.2	2,881,617.3	5,937.9	1933		31.6	N	-	-	-	-	
	TP-09-03	11/5/19	935				4077		68.9	N	-	-	-	-	
	TP-09-05	11/5/19	945				2053		33.7	N	-	-	-	-	
	TP-09-07	11/5/19	950				2644	Field QA/QC Dup	43.8	Y	47.0	5.7	1.2	47	
	TP-09-07-D	11/5/19	1000							Y	41.5	5.1	1.2	55	
TP-10	TP-10-01	11/5/19	1255	1,514,777.6	2,881,405.0	5,909.0	1301		20.6	N	-	-	-	-	
	TP-10-03	11/5/19	1300				1886			30.8	Y	31.0	3.7	0.7	39
	TP-10-06	11/5/19	1310				1610			26.0	N	-	-	-	-
	TP-10-08	11/5/19	1315				3535			59.5	N	-	-	-	-
TP-11	TP-11-01	11/5/19	1320	1,514,832.0	2,881,495.3	5,910.5	1156		18.1	N	-	-	-	-	
	TP-11-03	11/5/19	1325				1324		21.0	N	-	-	-	-	
	TP-11-06	11/5/19	1335				1633		26.4	Y	22.8	2.8	1.0	37	
	TP-11-08	11/5/19	1340				1646		26.6	N	-	-	-	-	
TP-12	TP-12-01	11/5/19	915	1,514,769.6	2,881,541.2	5,894.9	1707		27.7	Y	24.8	3.0	0.8	49	
	TP-12-03	11/5/19	910				2439		40.4	N	-	-	-	-	
	TP-12-06	11/5/19	900				1481		23.7	N	-	-	-	-	
TP-13	TP-13-01	11/4/19	1255	1,514,619.8	2,880,964.2	5,882.8	2220		36.6	N	-	-	-	-	
	TP-13-03	11/4/19	1300				2604		43.3	N	-	-	-	-	
	TP-13-06	11/4/19	1305				2316		38.3	Y	35.0	4.2	0.6	52	
	TP-13-08	11/4/19	1315				2188		36.0	N	-	-	-	-	

Table 1 (Continued)
St. Anthony Mine Site
Pit 1 Pile Investigation Soil Sample Results Summary

Test Pit Sample Information							Field Soil Gamma Screening Data			Laboratory Data				Laboratory Data
Test Pit ID	Sample ID	Sample Date	Sample Time	Northing NAD83 NM West (feet)	Easting NAD83 NM West (feet)	Test Pit Elevation (feet)	Sample CPM (net avg)	Comments	Estimated Ra-226 pCi/g	Sample Sent to Lab	Ra-226 pCi/g	Error Estimate pCi/g	MDC pCi/g	Uranium mg/Kg
TP-14	TP-14-01	11/4/19	1530	1,514,655.1	2,881,446.1	5,919.6	2657	FSS on 11/5	44.2	N	-	-	-	-
	TP-14-03	11/4/19	1540				1104	FSS on 11/5	17.2	N	-	-	-	-
	TP-14-07	11/4/19	1545				2409	FSS on 11/5	39.9	Y	40.0	4.8	1.0	31
	TP-14-08	11/4/19	1555				1802	FSS on 11/5	29.3	N	-	-	-	-
TP-15	TP-15-01	11/4/19	1455	1,514,592.1	2,881,305.6	5,900.9	1789		29.1	N	-	-	-	-
	TP-15-03	11/4/19	1500				2252		37.2	N	-	-	-	-
	TP-15-06	11/4/19	1505				2507		41.6	Y	35.5	4.3	0.8	26
	TP-15-07	11/4/19	1515				3630		61.1	N	-	-	-	-
TP-16	TP-16-01	11/4/19	1325	1,514,547.0	2,880,882.3	5,882.8	1644		26.6	N	-	-	-	-
	TP-16-03	11/4/19	1335				1582		25.5	N	-	-	-	-
	TP-16-07	11/4/19	1345				1749		28.4	N	25.5	3.1	0.6	38
	TP-16-09	11/4/19	1355				2036	Weight Corrected	33.4	Y	-	-	-	-
TP-17	TP-17-01	11/4/19	1055	1,514,531.7	2,881,025.3	5,911.4	993		15.2	N	-	-	-	-
	TP-17-03	11/4/19	1100				1201		18.9	Y	15.1	1.9	0.6	30
	TP-17-05	11/4/19	1105				1219		19.2	N	-	-	-	-
TP-18	TP-18-01	11/4/19	1415	1,514,630.9	2,881,198.0	5,900.6	2813	Weight Corrected	46.9	N	-	-	-	-
	TP-18-03	11/4/19	1420				2987	Weight Corrected	49.9	N	-	-	-	-
	TP-18-06	11/4/19	1425				2193		36.1	Y	34.7	4.2	1.0	46
	TP-18-08	11/4/19	1430				1899		31.0	N	-	-	-	-
TP-19	TP-19-01	11/4/19	1115	1,514,571.1	2,881,135.1	5,917.8	1460		23.4	N	-	-	-	-
	TP-19-03	11/4/19	1123				2039		33.4	Y	33.7	4.1	0.7	30
	TP-19-05	11/4/19	1130				1886		30.8	N	-	-	-	-
	TP-19-07	11/4/19	1140				2423		40.1	N	-	-	-	-

Table 2
St. Anthony Mine Site
Pit 1 Pile Investigation Ra-226 Results Summary

Pile ID	Test Pit ID	Test Pit Average Ra-226 pCi/g	Pile Average Ra-226 pCi/g
Pile 1	TP-01	103.5	77.2
	TP-02	67.9	
	TP-03	57.9	
	TP-04	71.7	
	TP-05	85.0	
Pile 2	TP-06	29.2	25.0
	TP-08	13.7	
	TP-10	34.2	
	TP-11	23.0	
Pile 3	TP-07	23.8	34.1
	TP-09	44.5	
Pile 4	TP-12	30.6	35.2
	TP-14	32.6	
	TP-15	42.2	
Pile 5	TP-13	38.5	31.5
	TP-16	28.5	
	TP-17	17.8	
	TP-18	41.0	
	TP-19	31.9	

Figure

Appendix A

Test Pit Geotechnical Logs

Appendix B
Field Soil Sample Gamma Radiation Screening Forms

Appendix C

Sample Chain of Custody and Laboratory Result Reports

Appendix D
Radiologic Instrument Calibration, Correlation and Operational Function Check
Documentation