Appendices

Appendix A St. Anthony Mine Site Gamma Survey Data (2007 Materials Characterization Surface Gamma Survey Data & Supplemental Characterization Gamma Scan Data Electronic File Compact Disc)

Summary of 2017 Material Characterization Gamma Radiation Survey Results		
	Gamma Exposure Rate	EquivalenSurface Soil
	@ 1-meter ags	Estimated Ba-226 pCi/a <sup>(1)</sup>
Ba	ckaround and Borrow Area	
Ba	ackground Reference Area	
		0.3
	11	0.3
	11	0.3
	13	1.3
	14	1.8
	17	3.2
BCKA L 2-1	13	1 3
BCKA L 2-2	15	23
BCKA L 2-3	17	3.2
BCKA L 2-4	16	27
BCKA L 2-5	18	37
BCKA L2-6	18	3.7
BCKA I 3-1	21	5.2
BCKA I 3-2	19	4.2
BCKA I 3-3	19	4.2
BCKA I 3-4	21	5.2
BCKA I 3-5	21	5.2
BCKA I 3-6	21	5.2
Mean	16	3.0
Minimum	11	0.3
Maximum	21	5.2
Maximum	Borrow Area South	5.2
BA3 L1-1	11	0.3
BA3 L1-2	26	7.6
BA3 L1-3	26	7.6
BA3 L1-4	25	7.2
BA3 L2-1	17	3.2
BA3 L2-2	16	2.7
BA3 L2-3	16	2.7
BA3 L2-4	16	2.7
BA3 L3-1	17	3.2
BA3 L3-2	13	1.3
BA3 L3-3	13	1.3
BA3 L3-4	15	2.3
BA3 L4-1	14	1.8
BA3 L4-2	13	1.3
BA3 L4-3	14	1.8
BA3 L4-4	17	3.2
BA3 L5-1	11	0.3
BA3 L5-2	14	1.8
Mean	16	2.9
Minimum	11	0.3
Maximum	26	7.6

Summary of 2017 Material Characterization Gamma Radiation Survey Results		
	Gamma Exposure Rate (uR/hr) Measurements	EquivalenSurface Soil
Location ID	@ 1-meter ags	Estimated Ra-226, pCi/g
	Lobo Tract Area	
L-1	16	2.7
L-2	7	<0.2
L-3	13	1.3
L-4	15	2.3
L-5	13	1.3
L-6	12	0.8
L-7	12	0.8
L-8	10	<0.2
L-9	11	0.3
L-10	15	2.3
L-11	15	2.3
L-12	15	2.3
L-13	15	2.3
L-14	15	2.3
L-15	17	3.2
L-16	16	2.7
L-17	15	2.3
L-18	14	1.8
L-19	14	1.8
L-20	15	2.3
L-21	14	1.8
Mean	14	1.9
Minimum	7	0.3
Maximum	17	3.2
	Former Borrow Areas	
Area 1		
BA1 L1-1	9	<0.2
BA1 L1-2	11	0.3
BA1 L1-3	11	0.3
BA1 L1-4	13	1.3
BA1 L1-5	11	0.3
BA1 L2-1	10	<0.2
BA1 L2-2	9	<0.2
BA1 L2-3	11	0.3
BA1 L2-4	8	<0.2
BA1 L2-5	11	0.3
BA1 L3-1	10	<0.2
BA1 L3-2	9	<0.2
BA1 L3-3	11	0.3
BA1 L3-4	8	<0.2
BA1 L3-5	12	0.8
BA1 L4-1	11	0.3
BA1 L4-2	8	<0.2
BA1 L4-3	10	<0.2

Summary of 2017 Material Characterization Gamma Radiation Survey Results		
	Gamma Exposure Rate (uR/hr) Measurements	EquivalenSurface Soil
		Estimated Ra-226, pCl/g
DA1 L4-4	11	0.3
BAT L4-5	9	<0.2
	12	0.8
BAT L5-2	9	<0.2
BAT LD-3	9	<0.2
BAT L5-4	10	<0.2
BAT LO-D	11	0.3
	10	-0.2
	10	<0.2
BA2 L1-2	9	<0.2
BA2 L1-3	10	<0.2
	9	<0.2
	13	1.3
	10	<0.2
BA2124	0	0.3
	0	<0.2
	0	<0.2
DA2 L3-2	0	0.3
DA2 L3-3	9	<0.2
	10	<0.2
	9	<0.2
BA2151	10	<0.2
BA215-1	9	<0.2
BA215-2	9	<0.2
BA2 L5-3	10	<0.2
BA216-1	11	0.3
BA216-2	11	0.3
BA216-3	10	<0.2
BA216-4	9	<0.2
BA2   7-1	11	0.3
BΔ217-2	9	<0.2
BΔ217-3	9	<0.2
BA217-4	13	1 3
BA2   8-1	Q 10	<0.2
BA218-2	8	<0.2
BA218-3	<u> </u>	<0.2
BA219-1	Q	<0.2
Mean	10	0.5
Minimum	8	0.3
Maximum	13	1.3

	Gamma Exposure Rate (uR/hr) Measurements	EquivalenSurface Soil
Location ID	@ 1-meter ags	Estimated Ra-226, pCi/g <sup>(1)</sup>
	Soil Stockpiles	
	Shale 1	
S1 L1-1	14	1.8
S1 L1-2	13	1.3
S1 L1-3	16	2.7
S1 L2-1	13	1.3
S1 L2-2	14	1.8
S1 L3-1	14	1.8
Mean	14	1.8
Minimum	13	1.3
Maximum	16	2.7
	Shale 2	
S2 L1-1	11	0.3
S2 L1-2	12	0.8
S2 L1-3	14	1.8
S2 L2-1	14	1.8
S2 L2-2	19	4.2
S2 L3-2	12	0.8
S2 L3-3	13	1.3
Mean	14	1.6
Minimum	11	0.3
Maximum	19	4.2
	Topsoil Pile South	
TS-110	12	0.8
TS-111	13	1.3
TS-112	12	0.8
TS-113	15	2.3
TS-267	13	1.3
TS-268	14	1.8
Mean	13	1.4
Minimum	12	0.8
Maximum	15	2.3
	Top Soil Pile North	
IS L2-1	16	2.7
TS L2-2	19	4.2
IS L2-3	22	5.7
	18	3.7
Mean	19	4.1
Minimum	19	2.7
Maximum	20	5.7

Summary of 2017 Material Characterization Gamma Radiation Survey Results		
	Gamma Exposure Rate	
	(uR/hr) Measurements	EquivalenSurface Soil
Location ID	@ 1-meter ags	Estimated Ra-226, pCi/g <sup>(1)</sup>
	Topsoil/Overburden Pile	
TS OB L1-1	25	7.2
TS OB L1-2	23	6.2
TS OB L1-3	22	5.7
TS OB L1-4	20	4.7
TS OB L1-5	16	2.7
TS OB L2-1	34	11.6
TS OB L2-2	34	11.6
TS OB L2-3	30	9.6
TS OB L2-4	25	7.2
Mean	25	7.4
Minimum	16	2.7
Maximum	34	11.6
	FL Area	
FL-264	51	19.9
FL-265	46	17.4
FL-266	31	10.1
Mine Ar	ea Non-Economic Material	s Piles
	Pile 3	
P3	60	24.3
P3 NE 117	105	46.4
P3 NW 116	70	29.2
P3 SE 115	65	26.8
P3 SW 114	65	26.8
P3-278	75	31.7
P3-279	36	12.5
P3-280	46	17.4
P3-281	65	26.8
P3-282	60	24.3
P3-283	46	17.4
P3-284	62	25.3
P3-286	70	29.2
P3-287	98	42.9
P3-288	165	75.8
P3-289	125	56.2
P3-290	80	34.1
P3-291	105	46.4
P3-292	105	46.4
P3-293	135	61.1
Mean	82	35.0
Minimum	36	12.5
Maximum	165	75.8

Summary of 2017 Material Characterization Gamma Radiation Survey Results		
	Gamma Exposure Rate (uR/hr) Measurements	EquivalenSurface Soil
Location ID	@ 1-meter ags	Estimated Ra-226, pCi/g ("
	Pile 4	
P4 L10-1	46	17.4
P4 L10-2	47	17.9
P4 L10-3	50	19.4
P4 L10-4	65	26.8
P4 L10-5	28	8.6
P4 L10-6	15	2.3
P4 L10-7	15	2.3
P4 L1-1	14	1.8
P4 L11-1	35	12.1
P4 L11-2	23	6.2
P4 L11-3	17	3.2
P4 L11-4	15	2.3
P4 L11-5	15	2.3
P4 L1-2	13	1.3
P4 L12-1	29	9.1
P4 L12-2	45	17.0
P4 L1-3	13	1.3
P4 L13-1	16	2.7
P4 L14-1	30	9.6
P4 L14-2	18	3.7
P4 L2-1	25	7.2
P4 L2-2	18	3.7
P4 L2-3	13	1.3
P4 L2-4	13	1.3
P4 L2-5	13	1.3
P4 L2-6	35	12.1
P4 L2-7	25	7.2
P4 L2-8	16	2.7
P4 L3-1	25	7.2
P4 L3-2	14	1.8
P4 L3-3	13	1.3
P4 L3-4	14	1.8
P4 L3-5	35	12.1
P4 L3-6	30	9.6
P4 L3-7	40	14.5
P4 L3-8	43	16.0
P4 L4-1	28	8.6
P4 L4-10	15	2.3
P4 L4-2	24	6.7
P4 L4-3	19	4.2
P4 L4-4	14	1.8
P4 L4-5	13	1.3
P4 L4-6	15	2.3
P4 L4-7	30	9.6

Summary of 2017 Material Characterization Gamma Radiation Survey Results		
	Gamma Exposure Rate (uR/hr) Measurements	EquivalenSurface Soil
Location ID	@ 1-meter ags	Estimated Ra-226, pCi/g <sup>(1)</sup>
P4 L4-8	24	6.7
P4 L4-9	21	5.2
P4 L5-1	36	12.5
P4 L5-10	27	8.1
P4 L5-11	25	7.2
P4 L5-2	27	8.1
P4 L5-3	30	9.6
P4 L5-4	31	10.1
P4 L5-5	17	3.2
P4 L5-6	14	1.8
P4 L5-7	18	3.7
P4 L5-8	55	21.9
P4 L5-9	17	3.2
P4 L6-1	60	24.3
P4 L6-2	26	7.6
P4 L6-4	22	5.7
P4 L6-5	18	3.7
P4 L6-6	34	11.6
P4 L6-7	40	14.5
P4 L7-1	55	21.9
P4 L7-2	38	13.5
P4 L7-3	24	6.7
P4 L7-4	42	15.5
P4 L7-4	55	21.9
P4 L7-5	58	23.3
P4 L7-6	60	24.3
P4 L7-7	41	15.0
P4 L7-8	26	7.6
P4 L8-1	65	26.8
P4 L8-10	32	10.6
P4 L8-11	16	2.7
P4 L8-2	45	17.0
P4 L8-3	30	9.6
P4 L8-4	21	5.2
P4 L8-5	19	4.2
P4 L8-6	19	4.2
P4 L8-7	18	3.7
P4 L8-8	20	4.7
P4 L8-9	55	21.9

Summary of 2017 Material Characterization Gamma Radiation Survey Results		
	Gamma Exposure Rate (uR/hr) Measurements	EquivalenSurface Soil
Location ID	@ 1-meter ags	Estimated Ra-226, pCi/g <sup>(1)</sup>
P4 L9-1	34	11.6
P4 L9-2	32	10.6
P4 L9-3	17	3.2
P4 L9-4	16	2.7
P4 L9-5	17	3.2
P4 L9-6	17	3.2
P4 L9-7	16	2.7
P4 L9-8	13	1.3
SW P-4	50	19.4
Mean	28	8.6
Minimum	13	1.3
Maximum	65	26.8
	Pile 5	
P5 L1-1	180	83.1
P5 L1-2	105	46.4
P5 L2-1	180	83.1
P5 L2-2	170	78.2
P5 L2-3	125	56.2
P5 L3-1	125	56.2
Mean	148	67.2
Minimum	105	46.4
Maximum	180	83.1
	Pile 6	
P6-234	80	34.1
P6-235	85	36.6
P6-236	100	43.9
P6-237	95	41.5
P6-238	95	41.5
P6-239	70	29.2
P6-240	115	51.3
P6-241	70	29.2
Mean	89	38.4
Minimum	70	29.2
Maximum	115	51.3
Pile 7		
P7-229	135	61.1
P7-230	230	107.6
P7-231	130	58.6
P7-232	245	115.0
P7-233	600	288.9
Mean	268	126.2
Minimum	130	58.6
Maximum	600	288.9

Summary of 2017 Material Characterization Gamma Radiation Survey Results		
	Gamma Exposure Rate (uR/hr) Measurements	EquivalenSurface Soil
Location ID	@ 1-meter ags	Estimated Ra-226, pCi/g <sup>(1)</sup>
	West Disturbance Area	
WDA-242	300	141.9
WDA-243	300	141.9
WDA-244	440	210.5
WDA-245	290	137.0
WDA-246	235	110.1
WDA-247	245	115.0
WDA-248	105	46.4
WDA-249	190	88.0
WDA-250	235	110.1
WDA-251	295	139.5
WDA-252	370	176.2
WDA-253	165	75.8
WDA-254	210	97.8
WDA-255	140	63.5
WDA-256	170	78.2
WDA-257	280	132.1
WDA-258	185	85.6
WDA-259	190	88.0
WDA-260	250	117.4
WDA-261	150	68.4
WDA-262	170	78.2
Mean	234	109.6
Minimum	105	46.4
Maximum	440	210.5
	Crusher/Stockpile Area	
CSA L1-1	75	31.7
CSA L1-2	65	26.8
CSA L1-3	79	33.6
CSA L1-4	75	31.7
CSA L1-5	85	36.6
CSA L1-6	105	46.4
CSA L2-1	190	88.0
CSA L2-2	105	46.4
CSA L2-3	175	80.7
CSA L2-4	195	90.5
CSA L2-5	195	90.5
CSA L2-6	205	95.4
CSA L2-7	140	63.5
CSA L3-1	135	61.1
CSA L3-2	120	53.7
CSA L3-3	220	102.7
CSA L3-4	320	151.7
CSA L3-5	220	102.7
CSA L3-6	240	112.5

Summary of 2017 Material Characterization Gamma Radiation Survey Results		
	Gamma Exposure Rate (uR/hr) Measurements @ 1-meter ags	EquivalenSurface Soil
CSA   3-7	265	124.8
CSA   4-1	280	132.1
CSA L4-2	490	235.0
CSA L4-3	175	80.7
CSA L4-4	215	100.3
CSA L4-5	800	386.9
CSA L4-6	350	166.4
CSA L4-7	330	156.6
CSA L5-1	250	117.4
CSA L5-2	330	156.6
CSA L5-3	200	92.9
CSA L5-4	175	80.7
CSA L5-5	410	195.8
CSA L5-6	210	97.8
CSA L5-7	220	102.7
CSA L6-1	95	41.5
CSA L6-2	240	112.5
CSA L6-3	240	112.5
CSA L6-4	160	73.3
CSA L6-5	125	56.2
CSA L6-6	215	100.3
CSA L6-7	245	115.0
CSA L7-1	155	70.9
CSA L7-2	450	215.4
CSA L7-3	155	70.9
CSA L7-4	180	83.1
CSA L7-5	235	110.1
CSA L8-1	80	34.1
CSA L8-2	180	83.1
CSA L8-3	100	43.9
Mean	214	99.9
Minimum	65	26.8
Maximum	800	386.9

	<b>a b b</b> (	
	Gamma Exposure Rate	EquivalenSurface Soil
Leastion ID	(uk/nr) Measurements	
Location ID	@ 1-meter ags	Estimated Ra-226, pul/g
		44.5
Pit1-165	95	41.5
Pit1-166	85	36.6
Pit1-167	70	29.2
Pit1-168	70	29.2
Pit1-169	62	25.3
Pit1-170	80	34.1
Pit1-171	70	29.2
Pit1-172	60	24.3
Pit1-173	80	34.1
Pit1-174	79	33.6
Pit1-175	138	62.5
Mean	81	34.5
Minimum	60	24.3
Maximum	138	62.5
	Western Shaft Area	
	Mine Dump	
MD-1	140	63.5
MD-2	225	105.2
MD-3	230	107.6
MD-4	215	100.3
MD-6	140	63.5
Mean	190	88.0
Minimum	140	63.5
Maximum	230	107.6
	Shaft Pad	
SP-1	70	29.2
SP-2	70	29.2
SP-3	50	19.4
Mean	63	25.9
Minimum	50	19.4
Maximum	70	29.2
	Storage Area	
SA-1	15	2.3
SA-2	15	2.3
Mean	15	2.3

Summary of 2017 Material Characterization Gamma Radiation Survey Results		
Location ID	Gamma Exposure Rate (uR/hr) Measurements @ 1-meter ags	EquivalenSurface Soil Estimated Ra-226, pCi/g <sup>(1)</sup>
	Shaft Area Ponds	
	300	141.9
SP2-2 (Pond 2)	260	122.3
SPM-6 (between Ponds 2 & 3)	22	5.7
SP3-3 (Pond 3)	95	41.5
SP4-4 (Pond 4)	390	186.0
P5-1 (Pond 5)	9	<0.2
P5-2 (Pond 5)	24	6.7
Mean	157	84.0
Minimum	9	5.7
Maximum	390	186.0
	Ore Storage Areas	
OS1-1	225	105.2
OS1-2	180	83.1
OS1-3	255	119.9
OS1-4	215	100.3
OS1-5	240	112.5
OS1-6	380	181.1
OS2-1	60	24.3
OS2-2	70	29.2
OS2-3	70	29.2
OS2-4	125	56.2
OS2-5	500	239.9
OS2-6	50	19.4
Mean	198	91.7
Minimum	50	19.4
Maximum	500	239.9

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	Gamma Exposure Rate	FouivalenSurface Soil
Location ID		Estimated Pa-226 pCi/g <sup>(1)</sup>
	Chaft Area Access Road	Estimateu Ra-220, poly
ΔR-01	24	67
	27	6.7
ΔR-02 ΔR-03	20	9.6
AR-03	18	3.0
AR-05	17	3.2
AR-06	70	29.2
AR-07	270	127.2
AR-08	80	34.1
AR-10	49	18.9
AR-11	60	24.3
AR-12	43	16.0
AR-13	65	26.8
AR-14	75	31.7
AR-15	240	112.5
AR-16	35	12.1
AR-17	75	31.7
AR-18	135	61.1
AR-19	135	61.1
AR-20	125	56.2
AR-21	36	12.5
AR-22	140	63.5
AR-23	100	43.9
AR-24	100	43.9
AR-25	60	24.3
AR-26	30	9.6
AR-27	22	5.7
AR-28	20	4.7
AR-29	22	5.7
AR-30	33	11.1
AR-31	40	14.5
AR-32	24	6.7
AR-33	17	3.2
AR-34	75	31.7
Mean	69	28.9
Minimum	17	3.2
Maximum	270	127.2

#### Notes:

(1) Surface soil Ra-226 in pCi/g estimated from site-specific surface gamma exposure rate (uR/hr) to surface soil Ra-226 Correlation [pCi/g Ra-226 = (0.49 x uR/hr)-5.10] for Ludlum Model 19 Micro R Meter

# Appendix B

# Subsurface Contamination Field Investigation Documentation

(Ex-Situ Gamma Soil Screening Reference soil Preparation Field Soil Sample Gamma Radiation Screening Forms Test Pit Geotechnical Field Sample Data Sheet Ex-Situ Soil Screening Gamma Radiation Level to Ra-226 Correlation Test Pit Subsurface Sample Laboratory Analytical Result Reports)

# AVM Environmental Services, Inc. Ra-226 Reference Soil Preparation for St. Anthony Gamma Radiation Soil Screening

The Ra-226 reference soil was prepared by local matrix soil from background area and 200 pCi/g PTW reference soil previously prepared for NECR PDS in 2013 using the Department of Energy's New Brunswick Laboratory (NBL) CRM 3-B (3.90% U $_3O_8$  with Ra to U weight ratio of 3.38E-07). The reference soil was prepared to calibrate the gamma radiation soil screening system for St. Anthony Site gamma soil screening for pit test during supplemental characterization. The gamma soil screening system will be utilized to determine if the subsurface soil sample is above or below the 6.6 pCi/g screening level. The matrix blending provides additional compensation for local background. The 200 pCi/g reference soil was diluted and mixed with the local matrix to bring the reference soil concentrations to 6.6 pCi/gm of Ra-226, slightly less than 6.0 pCi/g screening level to be conservative in soil screening.

115 grams of 200 pCi/g Reference Soil	= 23,000 pCi
4,000 grams of Matrix Soil (@1.0 pCi/g)	= 4,000 pCi
4,115 grams Total	= 27,000 pCi

# Reference Soil Ra-226 concentration = 6.6 pCi/g (April 14, 2018)

The reference and matrix soil was weighed using the Ohaus LS2000 electronic balance.

## AVM Envirential Services, Inc. Field Soil Sample Gamma Radiation Screening Form St. Anthony Mine Site

Instrumentation : Scaler/Ratemeter 2221 S#290802 Detector L-44-20 S#2 95573 Instrument Calibration Date: 8-1-17 test Survey Area/Unit Decsription Anthony

Date/Time	Soil Sample ID	Sample Weight Grams	609 (559-669) Kev Gross Counts, CP5M	Weight Corrected CP5M	СРМ	Ref Soil Comparision	Comments
4-16-18	Blank	-	363		73		
rt -	6.6 pCi/g Ref Soil	3000	3334		667		
11	SB-TP7-01 @ 927	3000	11490	-	2295	>	
10	SB-TP7-02 @936	3000	1218	diaman (	:244	2	Sample Cut
F)	SB-TP05-01 @ 1016	3000	9320		1864	>	
11	SB-TPOS-02 @1025	3000	114:30	<b>~</b> ~~	2286	>	
je	SB-TP05-03 @1030	3000	12870	~	2574	7	
(1	SBTP05-04 @1038	3000	13.750	~	2750	>	
įt.	SBTP05-05 @1052	3000	2480		496	2	Sample Cat
16	SBTP04-01 @ 1116	3000	7805	~	1561	7	
te	SBTP04-03 @1117	3000	17935	grime.	3587	7	
i,	SBTP04-05 @1125	3000	3704	-	741	>	
70	SBTP04-06 8/140	3000	2284	-	457	2	
74	SB-TPO6-01 @1204	3000	2010	~	402	2	Somple Cat
15	SB-TP09-03, E 1400	3000	1331		266	2	
Technician Si	gnature, Reviewed	by A-	ats				

## AVM Envire Intal Services, Inc. Field Soil Sample Gamma Radiation Screening Form St. Anthony Mine Site

Instrumentation : Scaler/Ratemeter (222) 5#29080, Detector L-14	-20 \$# 295573
Instrument Calibration Date: 8-1-17, Instrument Function	Check Performed:
Survey Area/Unit Decsription Antheny Test Pet	bit Screening

Date/Time	Soil Sample ID	Sample Weight Grams	609 (559-669) Kev Gross Counts, CP5M	Weight Corrected CP5M	СРМ	Ref Soil Comparision	Comments
4-16-18	SB-TP09-02 @1350	.3000	1337	-	267	4	Sample Cat
4-16-18	SB-TP09-01 6,340	3000	105-10	-	2108	>	
4-16-18	SB-TP08-03 81440	3000	1058	-	212	<	
le	SB-TP08-02 @1435	3000	1051	-	210	۷	Sample Cat
T t	SB-TP08-01 01430	3000	3666	-	733	~	Sample Cut
ic	SB-TP03-01 @1605	3008	1217	4 <b>8</b> 00	243	2	
4-17-18	Blank	~	392	-	78		
4-17-8	6.6 pCi/p Ref Sil	3000	3306	-	662		due to high Winds
4-18-18	Blank	-	406	-	81		
71	6.6 PC./ Ref So. 1	2000	3141	8 mil	628		
ti.	5B-TP10-01 8848	3000	4870	- 18 <sub>80 (</sub> .	974	>	Sample C-t
11	SB-TP10-02 6900	3000	2250		450	2	Sample Cut
Ti	SB-TP11-02 8920	3000	13370		2674	>	
11	SB-TP13-04 @ 1000	3000	16275		3255	>	
10	513-TP11-01 ( G911	BOACO	2665		533	2	
Technician Sig	gnature , Reviewed	by	hard				

## AVM Envirential Services, Inc. Field Soil Sample Gamma Radiation Screening Form St. Anthony Mine Site

Instrumentation : Scaler/Ratem	neter L2221 5#290	902 , Detector <u>144-20</u>	5#295573
Instrument Calibration Date:	8-1-17,	_, Instrument Function Check I	Performed:
Survey Area/Unit Decsription _	St. Anthony	test lit Soil	Screening_

Date/Time	Soil Sample ID	Sample Weight Grams	609 (559-669) Kev Gross Counts, CP5M	Weight Corrected CP5M	СРМ	Ref Soil Comparision	Comments
4-18-18	5B-TR13-06 @1022	30000	3961	-	792	7	Sample Cat
tr	SB -TP13-05 @ 1011	7000	8025	<u>~</u> .	1605	7	Somple Cat
14	SB-TP15-02 @1040	3000	1265	<b></b>	253	۷	Sample Cat
le	SB-TP15-01 @1036	30000	1234		247	<	Sample Cit
10	SB-TP11-03 G1111	7000	9395	~	1879	>	·
11	SB-TP.11-04 @1116	3000	11420		2284	>	Sample Cit
te	SB-TP11-05 8134	3000	2995	-	599	<	Sample Cit
11	SB-TP12-03 61226	3000	3266	q fran.	653	2	Sample Cut
ti.	SB-TP12-04 81235	3000	1937	l.	387	<	Sample C.t
61	SB-TP12-02 @1219	3000	5985	-	1197	>	
ų	SB-TP14-03 @ 1400	30100	1964	-	393	2	Sarple Cat
11	SB-TP14-02 @ 1350	3000	7259		1452	7	Sample Cot
11	SB-TP21-01 @1445	3000	1455	-	291	2	Sample Cat
te	SB-TP21-02 @1450	3000	1269		254	L.	Sumple Cat
11	SB-TP16-01 @ 1510	3000)	1207	program a real a mente "A generation "	242	2	Sample Cut
Technician Si	gnature, Reviewed	by	my	/			

AVM Envirential Services, Inc. Field Soil Sample Gamma Radiation Screening Form St. Anthony Mine Site .

Instrumentation : Scaler/Ratemeter	22215#290802 Detector	194-20 SH295573
Instrument Calibration Date:	-1-17, Instrument	Function Check Performed:
Survey Area/Unit Decsription	Anthing test	Ket Seil Screenry

Date/Time	Soil Sample ID	Sample Weight Grams	609 (559-669) Kev Gross Counts, CP5M	Weight Corrected CP5M	СРМ	Ref Soil Comparision	Comments
4-18-18	SB79602 61515	3000	1235	-	247	2	Sample Cut
t <sub>l</sub>	SB-TP17-01 @1530	3000	1377	y men	275	2	Sample Cat
17	SB. TP17-02 @1535	3000	1179	-	236	2	Sample Cat
10	SB-TP18-01 @ 1550	3000	1413	5	330	4	Sample Cat
te	SB-TP18-02 61555	3000	1379	-	276	<	Sample Cit
î,	SB-TP19-01 @ 1605	3000	9590	_	1918	>	Souple Cut
ŧ t	SB-7719-02 @ 1610	3000	1324	-	265	<	Sample Cat
4-19-18	Blank	-	360	-	72		
i,	6.6 pC/2 Ref S.)	3000	3139	~	628		
11	SB-TP22-07 @925	3000	1409		296	2	Sample Cat
li	SB-TP22-03 8 900	3000	3413		683	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Sample Cut
1.	5B-TP23-06 @1020	3000	2431	-	486	<	Sangle Cat
ŧ(	SB-TP23-04 @1010	3000	14350		2870	7	Souple Cat
11	SB-TP24 06 @ 1117	3000	17315	-	3463	7	Souple (it
t :	SB-TP24 05 @1106	Jase	13465	r	2693	>	Somple Cit
Technician Si	gnature, Reviewed	by	hang				

## AVM Envirental Services, Inc. Field Soil Sample Gamma Radiation Screening Form St. Anthony Mine Site

Instrumentation : Scaler/Ratemeter 2221 S#290	Detector (44-20 \$\$ 295573
Instrument Calibration Date:7	, Instrument Function Check Performed:
Survey Area/Unit Decsription Anthony	test (it Doil Screening

Date/Time	Soil Sample ID	Sample Weight Grams	609 (559-669) Kev Gross Counts, CP5M	Weight Corrected CP5M	СРМ	Ref Soil Comparision	Comments
4-19-18	SB-TP20-02 @1/40	3000	1342	•	268	2	Sumple Cut
4-19-18	SB-TP20-01 @ 1133	3000	1358	. – .	272	2	Sample Cart
ti	SB-7102-02 C1240	3000	1913	-	383	2	Somple Cut
1	SB-TP02-01 @1235	3000	11625	~	2325	>	Sample Cit
ч	SB-TPOI-02 @1310	3000	1430	~	286	2	SangleCit
10	SB-TPOI-01 @1300	3000	3670		734	>	Sample Cat
							,
Technician Sig	gnature Cartfact, Reviewed	by A	Any	· · · · · · · · · · · · · · · · · · ·	<u>L</u>	I	

4	general Pit tren Pit face	ST. ANTHONY FIELD SA GEOTECHNICAL TEST LOCATION: ID:	AMPLE DATA SHEET (FSDS) PIT LOGGING DATE: 4-19-18 FIELD ENGINEER: BICOMA Van EASTING: 2879801.1 Gamma Scan LCpm) JA,000 TEST PIT LOG
H		WR	LEGEND SOIL HORIZON HORIZON CONTRACT S GROUNDWATER LEVEL SAMPLE
Lft		mL	SAMPLE No. DEPTH TIME TYPE SB-TPOI-01 1.1+1 13:00 5 SB-TPOI-02 2.5+1 13:10 5 SB-TPOI-04 4 + 13.15 5
364			Pit Width: 4 ft Pit Width: 0 ft Pit Length: 0 ft Pit Depth: 4 ft GW Depth: N Pt
	SOIL UNIT WR	Soil DESCRIP Well graded grav dry. 1307.006018	tion and excavation notes el. Sond a cobbus. Light gray, 1005e, S, 407. gravel, 307. Sand)
ML	Native	Silt. Light brownin (57: Sandi 957 - Silt	ed culor. med. danse. dry f)
		CT ESDS Shoet No : GT	SPECIAL NOTES:

1ft	GENERAL PIT TREN PIT FACE	ST G LOCATIO D: LOGGEE	EOTEC			D SAMF ST PIT DA FIL		TA SH	EE SVC	T (FS	SDS)	Eest Pit IL Sheet NO NORTHING EASTING: PIT LO	D: <u>2</u> .: TP <u>15185</u> <u>2886</u> DG	27.1 209.9	
							LEGEND <u>LEGEND</u> SOIL HORIZON HORIZON CONTRACT GROUNDWATER LEVEL SAMPLE								
o (4		WR					SAMPLE No. DEPTH TIME TYPE SB-TP02-01 1-1 FT 12:35 S SB-TP02-02 2:55 12:40 S					* ula			
217 -				•	12				S	-					-
										Pit Pit Pit GW	Width: Length: Depth: Depth:	111 211 1.511 N.13			
USCS SYMBOL	SOIL UNIT			so	DIL DES	CRIPTION	AND E	XCAVATI	ON	NOTES	S	_			
GW ML	WR Natire	dry Sil	(2) (2) t. Li (57.5	ded b7 cc ght iand	grave bobles brown 1 95	e1. 50 5,45 n/red 7. sil	. Mea , t)	coloic ver, 3 tium prour	de	ma ma	ight ( nd) lo	ge. D	NY.		
						SPE	CIAL NO	TES:							
Cor	responding	GT F	SDS She	et No.:	GT			-							







					*			
230	general Pit Tren Pit Faci	ST. ANTHONY GEOTECHNIC, LOCATION: ND: US E LOGGED: US	FIELD SAMP AL TEST PIT  	LE DATA SHE LOGGING TE: <u>4-16-18</u> LD ENGINEER: <mark>BIC</mark>	ET (FSDS) anna Van TEST	est Pit ID Sheet NO. <i>NORTHING:</i> EASTING: PIT I C	: TP- 15104 28809	<u>462</u> 238.3
15+		native				GEND SOIL HORI HORIZON G GROUNDWA SAMPLE	ZON CONTRACT NTER LEVEL	
					SAMPLE NO. SBTPCCOOL	DEPTH	TIME 1/2:04	TYPE 5
	-		5					
	-				Pit Width: Pit Length: Pit Depth: GW Depth:	J.SFF SFF NA		2
USCS SYMBOL	SOIL	SO	L DESCRIPTION	AND EXCAVATION	N NOTES			
ml	inative 3011	Silt with training 907 silt si	cs coobles sand s	s. Dank lar 7. CULOUS	in co	Nor		
			SPEC	CAL NOTES:				
Cor	rresponding	g GT FSDS Sheet No.:	GT					
				5				
<b>4</b> : SOI	mple ser	1+ to 1ab						



	GENERA PIT TRE PIT FAC			Y FIELD SAN CAL TEST P	MPLE DATA S IT LOGGING DATE: 4-10 FIELD ENGINEER:	HEET (FSDS) -18 Breanm Va	Test Pit II Sheet NC <i>NORTHING</i> <i>EASTING</i>	D: <u>1108</u> D:: TP 2: <u>15161</u> 2: <u>15161</u> 2: 15161 2: 100	28.0 428.9	
1 Ft- 2 Ft-			Leoniver	>			EGEND - SOIL HOR - HORIZON GROUNDW, SAMPLE . DEPTH . DEPTH	TIME	TYPE S S S	**
361						Pit Width: Pit Length: Pit Depth: GW Depth:	2.5 <del>61</del> 10 <del>71</del> 361 NA	=		
USCS SYMBOL	SOIL UNIT NCUTIVE	Silt	. Same s ium de	soil description	DN AND EXCAVA	TION NOTES ROCIONONI (257) 50	n coir ind (s	DY 57) Si	1+(9	07.)
Cor	respondin	g GT FS	DS Sheet No	SF : GT	PECIAL NOTES:					
*: 9	sampies	sent	to loub							



+	general LC Pit Trend: Pit Face LC	ST. ANTHONY FIE GEOTECHNICAL CATION:	LD SAMPLE DATA SHEE TEST PIT LOGGING DATE: 4-18-18 FIELD ENGINEER: BM Jamma Com 22900	ET (FSDS) s Canna Van TEST	est Pit ID heet NO. <i>NORTHING:</i> EASTING: PIT_LC	: 10 : TP 151533 2882 )G	68 418.7	-
1#		Notive ML	15,000	LEC 	GEND SOIL HORI, HORIZON G GROUNDWA SAMPLE DEPTH 1 FF 2 FT	ZON CONTRACT MER LEVEL TIME 8:48 9:00	TYPE S S	58 1910
				Pit Width: Pit Length: Pit Depth: GW Depth:	.5 ft 3 ft 2 ft NA			
USCS SYMBOL	soil Unit Native D	soil d Wrk browntred	escription and excavation Silt. 957 Silt, 575	n notes	erette	y dun	<u>86</u>	
Corr	esponding G	T FSDS Sheet No.: GT-	SPECIAL NOTES:					
¥:201	mples se	nt to lab						

÷



		ST. ANTHONY FIELD S GEOTECHNICAL TEST	AMPLE DATA SHEET (FSDS) PIT LOGGING Test Pit ID: 12 Sheet NO.: TP
	GENERA PIT TRE PIT FAC	L LOCATION: ND: E-W EE LOGGED:	DATE: 4-18-18 NORTHING: 1914764.1 FIELD ENGINEER: Breanna Van EASTING: 2882599.4 Gamma Scan (cpm) TEST PIT LOG
2 <del>f</del> 1-		WR	<u>LEGEND</u> SOIL HORIZON HORIZON CONTRACT 23.000 SAMPLE
3ft		mi	SAMPLE No. DEPTH TIME TYPE SB-TP12-01 1 ft 12:09 S SB-TP12-02 2 ft 12:19 S
4#-		inative	SB-TP12:03 3.ft 12:20 S 4 SB-TP12:04 4.ft 12:39 S 4
Taxa a second			Pit Width: 4.5 ft Pit Length: 9 ft Pit Depth: 4 ft GW Depth: NA
USCS SYMBOL	SOIL	SOIL DESCRIF	TION AND EXCAVATION NOTES
GW	WR	Well graded gravel (107 cobbles, 507 gr	WISand a (obbles. White, 100se, dry. ravel, 40% sand)
ml	Native	Silt. Browhired cu 151 graves, 51.	sand, 907-silt)
			SPECIAL NOTES:
Cor	respondin	g GT FSDS Sheet No.: GT	
* Sar	npies s	ient to loub	

	GENERA PIT TRE PIT FAU	ST. ANTHONY FIELD SAMPLE DATA SHEET (FSDS) GEOTECHNICAL TEST PIT LOGGING ACE LOGGED: US ACE LOGGED: US COMPACING COM	7: <u>10</u> .: TP- <u>1514009.1</u> <u>28822250.3</u>	T T				
2.5 -		$\frac{30,000}{1000} \underbrace{\text{LEGEND}}{\text{Solution}}$ $\frac{30,000}{1000} \xrightarrow{\text{Soluthorizon}} = \underbrace{\text{Soluthorizon}}{\text{Solution}} = \underbrace{\text{Soluthorizon}}{\text{Soluthorizon}} = \underbrace{\text{Soluthorizon}}{ = \underbrace{\text{Soluthorizon}} = \text{Solu$						
USCS	SOIL	SOIL DESCRIPTION AND EXCAVATION NOTES						
ml	Native	Silt. 951 Silt ST Sand, plant material. Moist Me Medium I danc brown Sandstone bedrock @ 55ft. light gray, uniforma medium coarse grains	idium dens-	ę				
Co	rrespondin Hit b	SPECIAL NOTES:						

.


	GENER/ PIT TR PIT FA	S ( AL LOCA END: <u>E</u> CE LOGG	T. ANTHONY GEOTECHNIC TION:	FIELD SAMI   CAL TEST PIT   D <td< th=""><th>PLE DATA SH I LOGGING ATE: <u>4.18.18</u> HELD ENGINEER: P</th><th>IEET (FSDS) meanna Var ma(com) 18129 TES</th><th>Test Pit II Sheet NC NORTHING EASTING:</th><th>D: <b>15</b> D: TP <u>15144</u> <u>2887</u> OG</th><th>176-2 1323.8</th><th></th><th></th></td<>	PLE DATA SH I LOGGING ATE: <u>4.18.18</u> HELD ENGINEER: P	IEET (FSDS) meanna Var ma(com) 18129 TES	Test Pit II Sheet NC NORTHING EASTING:	D: <b>15</b> D: TP <u>15144</u> <u>2887</u> OG	176-2 1323.8		
ift -			ML Native			 کران مرام کران مرام	LEGEND soil hor horizon groundw sample	IZON CONTRACT ATER LEVEL	L		
24 -						SAMPLE SB:TPIS SB:TPIS SB:TPIS	No. DEPTH 01 1.164 102 2.64 03 3.567	пме 10:3ф 10:40 10:47	TYPE S S	**	Clear
3ft -						-S3D <sup>D</sup> Pit Width Pit Lengt	3ft- m 10ft-				
49-	1	1				GW Dept	NA	-			
SYMBOL ML	NCHIVE	Lig	sc hd brown. S ne small (	DIL DESCRIPTION	and excavation m clunse. D Her ( hours)	ON NOTES	and 1 957	sil+.			
				SPE	CIAL NOTES:						
Cor	respondin	g GT F	SDS Sheet No.:	GT							
<b>₩</b> .S	ample	sel	nt to lab								

	generai Pit Trei Pit Fac			LOGGING TE: 4.18.18 NORTHING: 1514 197.5 2882127.8 gamma scan (cpm) TEST PIT LOG
83 <sup>8</sup> 1f1- 2ft		WR NO <del>T</del>	ve	LEGEND 
USCS	SOIL			Pit Width: 4 ft Pit Length: 9 ft Pit Depth: 2 ft GW Depth: NP
SYMBOL	UNIT	s d with a	OIL DESCRIPTION	AND EXCAVATION NOTES
MT 2m	Native	Silt. Light (57. Sand, 9	57. silt)	57. graver) I. medium dense, dry.
Cor	respondin	g GT FSDS Sheet No	SPECI	IAL NOTES:
			Native (S	10 in

	GENERA PIT TRE PIT FAC	ST. ANTH GEOTEC L LOCATION: ND: NN-SE E LOGGED: LOO	HONY FIELD SA	AMPLE DATA SHI PIT LOGGING DATE: 418.18 FIELD ENGINEER: 9 GOT	EET (FS <u>reanna</u> ) nma sc 140.000	DS) s	est Pit ID Sheet NO. NORTHING: EASTING: DIT LO	: 17- : TP : 151413 28824 )G	9.3 112.10	1.4
1 <del>f)</del> 2 <del>f</del> J		Nati	WE)		9200 SAMF SB SB Pit Pit Pit Pit	LE No. 121701	GEND Soil HORI, HORIZON G GROUNDWA SAMPLE DEPTH 1.24 2.14 2.14 2.14	ZON CONTRACT ATER LEVEL 15:30 15:35	TYPE S S	
USCS	SOIL									
ML	Native	silt. Some brown. Loc	sand 4 grau seidry. (-	vel. some plo 257. gravel, 2	int m 157.sa	atter. nd, c	Ligh 201 · S	<b>t</b> i(t)		
				SPECIAL NOTES:						
Cor	rrespondir	g GT FSDS She Sent to 1	eet No.: GT							

	GENERAL PIT TREN PIT FACI	ST. ANTHONY FI GEOTECHNICAL LOCATION:	ELD SAMPLE DA TEST PIT LOGO DATE: FIELD ENG	Test Pit ID: 18 ATA SHEET (FSDS) Sheet NO.: TP- SING Sheet NO.: TP- SINEER: Breama Vaneasting: 15140658 GINEER: Breama Scan (Cpm) gamma Scan (Cpm)
14		Native		LEGEND SOIL HORIZON HORIZON CONTRACT GROUNDWATER LEVEL SAMPLE
2.11				SAMPLE No.     DEPTH     TIME     TYPE       NB·TP18·D     1.1     15:50     5       SB·TP18·02     2.1     15:55     5
en l'annan				
Trent			-	Pit Width: 4111 Pit Length: 7.5 ft Pit Depth: 2.1 ft GW Depth: NA
USCS SYMBOL	SOIL UNIT	SOIL	DESCRIPTION AND	EXCAVATION NOTES
ML	Native	Silt will some san Some plane mo	nd. Light bri outler	swh. Loose, dry. 1457. sand, 957. silt)
			SPECIAL N	OTES:
Cor	respondin (1)mn\P	g GT FSDS Sheet No.: G SCN1 to 1040	Τ	

GENE PIT T PIT F	ST. ANTHONY FIELD SAMF GEOTECHNICAL TEST PIT RAL LOCATION: DA REND: FIL ACE LOGGED:	LE DATA SHEET (FSDS) LOGGING TE: 4.18 Sheet NO.: TP- NORTHING: 1514025.5 LD ENGINEER: Breanna Van gamma scan (Lprn) LOGGING: 28833.01.9 LOGGING: 288
18	WR	LEGEND SOIL HORIZON HORIZON CONTRACT SC GROUNDWATER LEVEL SAMPLE
2.fi		SAMPLE No. DEPTH TIME TYPE JB:TP19:01 1.3 ft 16:05 S JB:TP19:02 2.3 ft 16:10 S
05	Native	
		Pit Width: 4 Ff Pit Length: 9 Ff Pit Depth: 2.3 Ff GW Depth: NA
USCS SOIL SYMBOL UNIT	SOIL DESCRIPTION	AND EXCAVATION NOTES
SW WR	Wellgraded sand wildn dry. [157. cobbles, 30	Quel & colobbes. Light gray. Loose, 57. gravel, 557. sand)
ML Nativ	brown I red. (257. grav	el, < Si · Saha 1901. sik)
	SPE	CIAL NOTES:
Correspond	ing GT FSDS Sheet No.: GT	

	GENERAL PIT TRENI PIT FACE			GING GING GINEER: Breaching ON EASTING: 1513518 GINEER: Breaching ON EASTING: 2884947 Gamma Scan (CPR) GINEER: DICLING
19		Native		
USCS SYMBOL	SOIL UNIT Native	son Dark brown. Silf Louse, dry	IL DESCRIPTION AND I	GW Depth: NH EXCAVATION NOTES Maher. (51.gravel, 107. sand, 857. silf)
	esponding	GT FSDS Sheet No.:	SPECIAL NO GT- ICO. Original	Tocation was inaccessible.

	generai Pit tre Pit fac	GEOTECHNICAL TEST PIT	LOGGING ATE: 4.18.18 NORTHING: 1913857.6 NORTHING: 1913857.6 2881478.5 Gamma Scan (CDM) 34.000 TEST PIT LOG
- 2		WRIND Lism) Native Soilin	LEGEND 
transfer for the second			Pit Width: <u>3.5ft</u> Pit Length: <u>3.5ft</u> Pit Length: <u>3.5ft</u> Pit Depth: <u>2 ft</u> GW Depth: <u>NA</u>
USCS SYMBOL	SOIL UNIT	SOIL DESCRIPTION Light group Waste nou	K Grower WI Sand & some cobbles L (10% cobble, sof gravel, q
ML	Native	light brown/red. silt	. (57. sand, 957. silt) medium dunse.
		SPE	ECIAL NOTES:
Cor	respondin	g GT FSDS Sheet No.: GT	

1





Con	respondi	ng GT FSDS Sheet No.: GT-	
		SI	PECIAL NOTES:
Sp-sc		Loose on istgrau	el,907. Sand, 57. silt), Greenish tint
1112		dunse Uniform grain	1. Brown uniform grains mustly
m		Silt. Some plant m	atter. Dansgreen work. Medium
GW	WA	Well graded gravel w	Isanda cobbles. Light gray 100se ary.
USCS SYMBOL	SOIL	SOIL DESCRIPTIO	ON AND EXCAVATION NOTES
Liter			Pit Length: 10.5 H Pit Depth: 10.5 H GW Depth: NP?
			Pit Width: 4.5 ft
641			
111		SP-SC	SB-TP24-06 5.5ft 11:06 S # 30 SB-TP24-06 6.5ft 11:17 S # 30
AG		(()~	SB-TP24-02 1974 10:35 S SB-TP24-02 1974 10:40 S SB-TP24-02 1974 10:40 S
2.ft		m	
1111		Wer	32,000 <u>LEGEND</u> SOIL HORIZON HORIZON CONTRACT
111			TEST PIT LOG
	GENER PIT TR PIT FA	AL LOCATION: END: <u>NE'SN</u> ICE LOGGED: <u>YES</u>	FIELD ENGINEER: Breanna Van EASTING: 2884557.1 gamma Scan LCPM)
		ST. ANTHONY FIELD SAN GEOTECHNICAL TEST P	MPLE DATA SHEET (FSDS) IT LOGGING

AVM Environmental Services Ex-Situ Soil Screening Gamma Radiation Level to Ra-226 Correlation St Anthony Mine Site Test Pit Investigation

Reference Soil ID	Date	Ra-226 pCi/g	Wt gms	609 KeV CP5Min Gross (3x3 Nal Detector)	CPM
Blank	4/14/2018	0	-	389	78
BKG Soil	4/14//18	1	3000	1522	304
SA Ref Soil	4/14//18	6.6	3000	3392	678
NECR PTW Ref Soil	4/14//18	100	3000	41400	8280



0.999887918 0.999775848 0.999663772 0.895185294

Multiple R R Square Adjusted R Square Standard Error Observations

**Regression Statistics** 

SUMMARY OUTPUT

		_
		_

ANUVA					
	df	SS	MS	F	Significance F
Regression		1 7148.517287	7148.517287	8920.518403	0.000112082
Residual		2 1.602713422	0.801356711		
Total		3 7150.12			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-1.80557978	0.541028323	-3.33731101	0.079258065	-4.13343677	0.522277213	-4.13343677	0.522277213
X Variable 1	0.01229282	0.000130154	94.44849604	0.000112082	0.011732814	0.012852827	0.011732814	0.012852827

AVM Envi. Jatal Services, Inc. Field Soil Sample Gamma Radiation Screening Form St. Authony Mine Site

Instrumentation : Scaler/Ratemeter (22731 (# 240802), Detector h. 44-20 (# 295573) , Instrument Function Check Performed: Instrument Calibration Date: 04-14-2018 Survey Area/Unit Decsription Coxpelation

					T	T				
Comments										
Estimated Ra- 226 pCi/g	Ø	1.0	4.6	100						
CPM	18	304	678	8280						
Weight Corrected Counts	١	l	J	١						
609 (559-669) Kev Gross Counts	389	1522	3392	ach lh						5
Sample Weight Grams	١	3000	3000	3000					1 A	
Soil Sample ID	Clark	St. Antry Bankground Soil	51. Arthing 6.6 PCE/9 Refame Soli	100 filg Reference Soil						11
Date/Time	1-14-18	Huldus	81-11-1	オーカトト						



# Gamma Spectroscopy Case Narrative

# Stantec

# St. Anthony Geotechnical Investigation – 233001076

## Work Order Number: 1804523

- 1. The following report consists of analytical results for 10 soil samples received by ALS on 04/24/2018.
- 2. These samples were prepared according to the current revision of SOP 739. The samples were sealed in steel cans on 05/02/2018 and stored for at least 21 days to allow <sup>222</sup>Rn to approach secular equilibrium with its parent, <sup>226</sup>Ra. The degree of ingrowth achieved prior to analysis on 05/23/2018 is at least 97.8%. Conservatively assuming a radon emanation efficiency of approximately 50%, the effective radon progeny ingrowth for these samples would be greater than 98.9%.
- 3. The samples were analyzed for the presence of gamma emitting radionuclides according to the current revision of SOP 713. The analyses were completed on 05/23/2018.
- 4. The results for these samples are reported on a "Dry Weight" basis in units of pCi/gram.
- 5. ALS has observed a reproducible low bias in <sup>226</sup>Ra results (about -30% for the geometry in question) when using a mixed gamma source for the calibration of HPGe detectors for solid samples. This bias is eliminated by calibration using a NIST traceable <sup>226</sup>Ra source in the same geometry and configuration as the samples.
- 6. The library used for calibration and analysis employs multiple peaks for the <sup>226</sup>Ra progeny, <sup>214</sup>Pb (352 and 295 keV) and <sup>214</sup>Bi (609 and 1120 keV). Using these peaks avoids the use of the problematic <sup>226</sup>Ra photopeak at 186 keV, which suffers from poorly resolvable interference from <sup>235</sup>U at the same energy. Final activity results for <sup>226</sup>Ra are calculated, using the uncertainty-weighted mean of the activities for the four photopeaks, by the Seeker gamma spectroscopy software assuming secular equilibrium.
- 7. The requested detection was not met for samples 1804523-1, -2, -5, -6, -9, and -10. The reported activity exceeds the achieved MDC. Results are submitted without further qualification. The results are flagged with an "M3" qualifier on the final reports.



8. No further problems were encountered with either the client samples or the associated quality control samples. All remaining quality control criteria were met.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

00 Pik Yee Yuen Radiochemistry Primary Data Reviewer

Radiochemiş Final Data Reviewer

5/24/18 Date

5/29/18 Date

# **ALS -- Fort Collins**

## Sample Number(s) Cross-Reference Table

OrderNum: 1804523 Client Name: Stantec Client Project Name: St. Anthony Geotechnical Investigation Client Project Number: 233001076 Client PO Number: 233001076

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
SB-TP19-01	1804523-1		SOIL	18-Apr-18	16:05
SB-TP19-201	1804523-2		SOIL	18-Apr-18	16:05
SB-TP19-02	1804523-3		SOIL	18-Apr-18	16:10
SB-TP10-01	1804523-4		SOIL	18-Apr-18	8:48
SB-TP10-201	1804523-5		SOIL	18-Apr-18	8:48
SB-TP10-02	1804523-6		SOIL	18-Apr-18	9:00
SB-TP15-01	1804523-7		SOIL	18-Apr-18	10:36
SB-TP15-02	1804523-8		SOIL	18-Apr-18	10:40
SB-TP13-05	1804523-9		SOIL	18-Apr-18	10:11
SB-TP13-06	1804523-10		SOIL	18-Apr-18	10:22

	<b>ALS Environmental</b>		Сh	lain-of-Cust	tody					
	225 Commerce Drive, Fort Collins, Colorado 80524 TF: (800) 443-1511 PH: (870) 480-1511 FX: (870) 480-152	122				Form 202rs		i Bous	523	
(ALS)		SAMPLER	Breanna Van		DATE	31-01-5	PAGE		of	
PROJECT NAME	t St. Anthony	81ED	St. Anthony		TURNAROUND	Standard	DISPOSAL	By Labo	r Return t	to Client
PROJECT No.	233001076	EDD FORMAT								F
		PURCHASE ORDER			 [y]			-		
COMPANY NAME	Stantec	BILL TO COMPANY	Stantec							
SEND REPORT TO	Toby Leeson	INVOICE ATTN TO	Melanie Davis							
ADORESS	2103 Resort Dr. Suite 350	ADDRESS	3325 S. Timberline Rd	Suite 150	10	_				
CITY / STATE / ZIP	Steamboat, CO 80487	CITY / STATE / ZIP	Fort Collins, CO 80525	2	6				_	
PHONE	970-871-4361	PHONE	970-212-2749		) १	2				
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E-WAIL	toby.leeson@stantec.com	E	melanie.davis@stant	tec.com	D			$\overline{}$		
9	Tadd D	×i	eg e sampt s	8 8 8						
1	50-7019-01	s 4.18	1 50.91 81	NA	>			 		
2	58-7019-201	s 4-18	18 he. 05 1	AN 4	>					
3	58-7P19-02	s 4-18	1 01:01 21-	NA I	×					
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S	5B-TP10-201	s 4-18	18848	NA NA						
¢	5B-1PID-02	s 4-)8	-18 9.00 1	NA I						
7	SB-7015-01	s 4-18	1 2 C O I 31-	NA						
8	SB-7P15-02	s 418	18/10:40 1	NA					Z	
9	58-7913-05	s 4-18	- 12 10:11 1	NA	$\mathbf{v}$					
01	58-7013-00	s  418	5-18 10:22 1	NA						-
"Time Zone (Circle): Ecomosolo os out	EST CST MST PST Matrix O = oil S = soil	NS = non-soil solid W = w	vater L = liquid E = extract F	F = filter						
	ions, prease oetan anarytes below.				SIGNALL		KIN TED NAME			

4/123118 12:05 Nick Jostes RELINQUISHED BY RELINQUIGHED BY RECEIVED BY

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LEVEL III (Sid QC + forms) LEVEL IV (Sid QC + forms + raw data) LEVEL II (Standard QC) 1-HCI 2-HNO3 3-H2SO4 4-NaOH 5-NaHSO4 7-Other 8-4 degrees C 9-5035 OC PACKAGE (check below) 4 of 20 Comments:

## ALS Environmental - Fort Collins CONDITION OF SAMPLE UPON RECEIPT FORM

(ALS)						
Client: <u>Stantec</u> Workorder No: 1801	1523		_			
Project Manager: LS Initials: 10	Date:	41241	- 18			
1. Does this project require any special handling in addition to standard ALS procedures?		YES	- 10			
2. Are custody seals on shipping containers intact?	NODE	YES	NO			
3. Are Custody seals on sample containers intact?	NONE	YES	NO			
4. Is there a COC (Chain-of-Custody) present or other representative documents?	-0	<b>E</b> S	NO			
5. Are the COC and bottle labels complete and legible?		YES	NO			
<sup>6.</sup> Is the COC in agreement with samples received? (IDs, dates, times, no. of samples, no. of containers, matrix, requested analyses, etc.)	+	K Ess	NO			
7. Were airbills / shipping documents present and/or removable?	DROP OFF	YES	NO			
3. Are all aqueous samples requiring preservation preserved correctly? (excluding volatiles)	N/A	YES	NO			
Are all aqueous non-preserved samples pH 4-9?	N/A)	YES	NO			
10. Is there sufficient sample for the requested analyses?		¥755	NO			
1. Were all samples placed in the proper containers for the requested analyses?		(B)	NO			
<sup>12</sup> Are all samples within holding times for the requested analyses?						
13. Were all sample containers received intact? (not broken or leaking, etc.)						
<sup>4</sup> Are all samples requiring no headspace (VOC, GRO, RSK/MEE, Rx CN/S, radon) headspace free? Size of bubble: < green pea> green pea	NA	YES	NO			
s. Do any water samples contain sediment?   Amount     Amount of sediment:	Ø.	YES	NO			
6. Were the samples shipped on ice?		YES	®)			
<sup>7</sup> Were cooler temperatures measured at 0.1-6.0°C? <sup>IR gun</sup> used*: #1 #3 #4	AND AND	YES	Ø			
Cooler #:		<u>/</u> /				
Temperature (°C): <u>Amb</u>		,				
No. of custody seals on cooler: O						
Acceptance External µR/hr reading:						
Background μR/hr reading: 9						
Were external $\mu$ R/hr readings $\leq$ two times background and within DOT acceptance criteria? YES / NO / NA (If no, see	e Form 008.)					
Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE, EX	CEPT #1 AN	D#16.				

If applicable, was the client contacted? YES / NO / NA Contact: Date/Time: \_ 4 26/18 Project Manager Signature / Date: \_\_\_\_ 7 Z

.....

\*IR Gun #1, VWR SN 170560549 \*IR Gun #3, VWR SN 170647571 \*IR Gun #4, Oakton, SN 2372220101-0002

# 1804523



## Gamma Spectroscopy Results PAI 713 Rev 14 Method Blank Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Lah	יחו	GS180502-1MB
Lap	ID:	G3100302-11VID

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 29-Apr-18 Date Prepared: 29-Apr-18 Date Analyzed: 23-May-18 Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Run ID: GS180502-1A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 180611d09

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0 +/- 0.23	0.42	0.5	NA	U

### **Comments:**

#### Qualifiers/Flags:

- U  $\,$  Result is less than the sample specific MDC or less than the associated TP
- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- M Requested MDC not met.
- B Analyte concentration greater than MDC.
- B3 Analyte concentration greater than MDC but less than Requested MDC.
- DL Decision Level

## Data Package ID: GSS1804523-1

Abbreviations:

TPU - Total Propagated Uncertainty

- MDC Sample specific Minimum Detectable Concentration
- **BDL** Below Detection Limit

## **Gamma Spectroscopy Results**

PAI 713 Rev 14

Laboratory Control Sample(s)

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

#### Lab ID: GS180502-1LCS

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 29-Apr-18 Date Prepared: 29-Apr-18 Date Analyzed: 23-May-18 Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Run ID: GS180502-1A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 180626d10

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Contro I Limits	Lab Qualifier
13982-63-3	Ra-226	462 +/- 54	2	468.3	98.6	85 - 115	P,M3

### **Comments:**

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP TPU - Total Propagated Uncertainty LT - Result is less than Requested MDC, greater than sample specific MDC. MDC - Minimum Detectable Concentration Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed. Y2 - Chemical Yield outside default limits. SQ - Spectral quality prevents accurate quantitation. L - LCS Recovery below lower control limit. SI - Nuclide identification and/or quantitation is tentative. H - LCS Recovery above upper control limit. TI - Nuclide identification is tentative. P - LCS Recovery within control limits. R - Nuclide has exceeded 8 halflives. M - The requested MDC was not met. M3 - The requested MDC was not met, but thereported activity is greater than the reported MDC.

## Data Package ID: GSS1804523-1

Abbreviations:

## **Gamma Spectroscopy Results**

PAI 713 Rev 14 Duplicate Sample Results (DER)

Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID: S Lab ID: 1 Lib	B-TP15-01 804523-7DUP <b>rary:</b> RA226.LIB	Sample Matrix: SOIL Prep SOP: PAI 739 Date Collected: 18-Apr-1 Date Prepared: 29-Apr-1 Date Analyzed: 23-May-	Rev 12 8 8 18	Prep E QCBat Ri Count Report E	atch: GS180502-1 chID: GS180502-1-1 un ID: GS180502-1A Time: 30 minutes Basis: Dry Weight	Final Aliquot: 198 g Prep Basis: Dry Weigl Moisture(%): NA Result Units: pCi/g File Name: 180624dC		ght 08	
CASNO	Analyte	Sample Result +/- 2 s TPU	MDC	Flags	Dupli Result +/- 2 s TPU	cate MDC	Flags	DER	DER Lim
13982-63-3	Ra-226	1 04 +/- 0 24	0.36		1 17 +/- 0 27	0.38		0.351	2 13

## Comments:

Duplicate Qualifiers/Flags:		Abbreviations:
U - Result is less than the sample specific MDC.		TPU - Total Propagated Uncertainty
Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.		DER - Duplicate Error Ratio
Y2 - Chemical Yield outside default limits.		BDL - Below Detection Limit
W - DER is greater than Warning Limit of 1.42		NR - Not Reported
D - DER is greater than Control Limit of 2.13		
LT - Result is less than Request MDC, greater than sample specific MDC		
M - Requested MDC not met.		
M3 - The requested MDC was not met, but the reported	SQ - Spectral quality prevents accurate quantitation.	
1 - LCS Recovery below lower control limit	SI - Nuclide identification and/or quantitation is tentative.	
H - LCS Recovery above upper control limit	TI - Nuclide identification is tentative.	
P-LCS Matrix Spike Recovery within control limits	R - Nuclide has exceeded 8 halflives	
N - Matrix Spike Recovery outside control limits	G - Sample density differs by more than 15% of LCS density	

## Data Package ID: GSS1804523-1

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:     SB-TP19-01       Lab ID:     1804523-1	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Run ID: GS180502-1A	Final Aliquot: 225 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180915d03

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	29.0 +/- 3.6	0.9	0.5	NA	M3

## **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804523-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:     SB-TP19-201       Lab ID:     1804523-2	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Run ID: GS180502-1A	Final Aliquot: 228 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180/10007

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	26.8 +/- 3.3	0.7	0.5	NA	M3

## **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804523-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:     SB-TP19-02       Lab ID:     1804523-3	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Run ID: GS180502-1A	Final Aliquot: 224 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180610d09

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.90 +/- 0.24	0.42	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804523-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:     SB-TP10-01       Lab ID:     1804523-4	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Run ID: GS180502-1A	Final Aliquot: 213 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180625d10

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	15.1 +/- 1.8	0.5	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

DL - Decision Level

## Data Package ID: GSS1804523-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:     SB-TP10-201       Lab ID:     1804523-5	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Bun ID: GS180502-1A	Final Aliquot: 214 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180722d01

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	8.1 +/- 1.1	0.6	0.5	NA	M3

## **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804523-1

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:     SB-TP10-02       Lab ID:     1804523-6	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Bun ID: GS180502-14	Final Aliquot: 215 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed. 25 May 10	Report Dasis. Dry Weight	

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	5.03 +/- 0.70	0.58	0.5	NA	M3

## **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804523-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:     SB-TP15-01       Lab ID:     1804523-7	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Run ID: GS180502-1A	Final Aliquot: 196 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180567d05

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.04 +/- 0.24	0.36	0.5	NA	

## Comments:

### Qualifiers/Flags:

- U  $\,$  Result is less than the sample specific MDC or less than the associated TP
- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804523-1

- SQ Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

## **Gamma Spectroscopy Results**

PAI 713 Rev 14

Sample Duplicate Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:     SB-TP15-01       Lab ID:     1804523-7DUP	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Run ID: GS180502-1A	Final Aliquot: 198 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180624d08

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.17 +/- 0.27	0.38	0.5	NA	

### **Comments:**

#### Qualifiers/Flags:

- U Result is less than the sample specific MDC or less than the associated TPU.
- Y1 Chemical Yield is in control at 100-110%. Quantitative yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M The requested MDC was not met.
- M3 The requested MDC was not met, but thereported activity is greater than the reported MDC.
- W DER is greater than Warning Limit of 1.42
- D DER is greater than Control Limit of 2.13

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- **BDL** Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804523-1

## Date Printed:

Thursday, May 24, 2018

SQ - Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.

G - Sample density differs by more than 15% of LCS density.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:     SB-TP15-02       Lab ID:     1804523-8	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Run ID: GS180502-1A	Final Aliquot: 205 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 181120d04

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.76 +/- 0.25	0.45	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804523-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:     SB-TP13-05       Lab ID:     1804523-9	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Run ID: GS180502-1A	Final Aliquot: 185 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180916d03

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	12.6 +/- 1.6	0.8	0.5	NA	M3

## Comments:

### Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804523-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1804523

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Library: RA226.LIB Date Prepared: 29-Apr-18 Count Time: 30 minutes Result Units: pCi/g Date Analyzed: 23-May-18 Report Basis: Dry Weight File Name: 180711d07	Field ID:     SB-TP13-06       Lab ID:     1804523-10	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-1 QCBatchID: GS180502-1-1 Bun ID: GS180502-14	Final Aliquot: 184 g Prep Basis: Dry Weight Moisture(%): NA
Date Analyzed: 23-May-18 Report Basis: Dry Weight File Name: 180711d07	Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
		Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180711d07

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	6.93 +/- 0.95	0.58	0.5	NA	M3

## Comments:

### Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804523-1

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.



# Gamma Spectroscopy Case Narrative

# Stantec

# St. Anthony Geotechnical Investigation – 233001076

## Work Order Number: 1804521

- 1. The following report consists of analytical results for 11 soil samples received by ALS on 04/24/2018.
- 2. These samples were prepared according to the current revision of SOP 739. The samples were sealed in steel cans on 05/02/2018 and stored for at least 21 days to allow <sup>222</sup>Rn to approach secular equilibrium with its parent, <sup>226</sup>Ra. The degree of ingrowth achieved prior to analysis on 05/23/2018 is at least 97.8%. Conservatively assuming a radon emanation efficiency of approximately 50%, the effective radon progeny ingrowth for these samples would be greater than 98.9%.
- 3. The samples were analyzed for the presence of gamma emitting radionuclides according to the current revision of SOP 713. The analyses were completed on 05/23/2018.
- 4. The results for these samples are reported on a "Dry Weight" basis in units of pCi/gram.
- 5. ALS has observed a reproducible low bias in <sup>226</sup>Ra results (about -30% for the geometry in question) when using a mixed gamma source for the calibration of HPGe detectors for solid samples. This bias is eliminated by calibration using a NIST traceable <sup>226</sup>Ra source in the same geometry and configuration as the samples.
- 6. The library used for calibration and analysis employs multiple peaks for the <sup>226</sup>Ra progeny, <sup>214</sup>Pb (352 and 295 keV) and <sup>214</sup>Bi (609 and 1120 keV). Using these peaks avoids the use of the problematic <sup>226</sup>Ra photopeak at 186 keV, which suffers from poorly resolvable interference from <sup>235</sup>U at the same energy. Final activity results for <sup>226</sup>Ra are calculated, using the uncertainty-weighted mean of the activities for the four photopeaks, by the Seeker gamma spectroscopy software assuming secular equilibrium.
- 7. The requested detection was not met for samples 1804521-1, -1DUP, -2, -8, and -10. The reported activity exceeds the achieved MDC. Results are submitted without further qualification. The results are flagged with an "M3" qualifier on the final reports.



8. No further problems were encountered with either the client samples or the associated quality control samples. All remaining quality control criteria were met.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

400  $\mathcal{M}$ ner Pik Yee Yuen

Radiochemistry Primary Data Reviewer

Radioch mistry Final Data Reviewer

<u>5/24/18</u> Date

5/29/18 Date

# **ALS -- Fort Collins**

## Sample Number(s) Cross-Reference Table

OrderNum: 1804521 Client Name: Stantec Client Project Name: St. Anthony Geotechnical Investigation Client Project Number: 233001076 Client PO Number: 233001076

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
SB-TP07-01	1804521-1		SOIL	16-Apr-18	9:27
SB-TP07-201	1804521-2		SOIL	16-Apr-18	9:27
SB-TP07-02	1804521-4		SOIL	16-Apr-18	9:36
SB-TP05-05	1804521-5		SOIL	16-Apr-18	10:52
SB-TP04-05	1804521-6		SOIL	16-Apr-18	11:30
SB-TP04-06	1804521-7		SOIL	16-Apr-18	11:47
SB-TP06-01	1804521-8		SOIL	16-Apr-18	12:04
SB-TP09-02	1804521-9		SOIL	16-Apr-18	13:50
SB-TP08-01	1804521-10		SOIL	16-Apr-18	14:30
SB-TP08-02	1804521-11		SOIL	16-Apr-18	14:35
SB-TP03-01	1804521-12		SOIL	16-Apr-18	16:05

or Return to Client 1/25 has,1 ور لح By Lab PAGE DISPOSAL MORKORDER . DATE 4.17.2018 Form 202rB Le la la TURNAROUND Chain-of-Custody (5-1: PH 1106 922-34 2 > > > 7 > > > 2 8 ٩ ¥ Pres. ¥ ٩ ₹ ₹ ٩ ٩ ٩N 3325 S. Timberline Rd Suite 150 ٩ melanie.davis@stantec.com Bottes \*5 4 4 4 3 Fort Collins, CO 80525 4 2 ٣ 2 -1 Matrix: O = oil S = soil NS = non-soil solid W = water L = liquid E = extract 9:27 4.16.12 9:27 4-16-18 9:21.4 970-212-2749 Sample Time 13:50 = : <del>2</del> 4-16-18 14:47 4-16-18 12:04 12:01 Melanie Davis 9:36 Breanna Van St. Anthony Stantec 4.16.18 4.16.18 4.16.12 7-16-18 21.51.4 Sample Date E-MAIL INVOICE ATTN TO **ADDRESS** PHONE SAMPLER SITE ID BILL TO COMPANY FAX EDD FORMAT CITY / STATE / ZP PURCHASE ORDER Matrix S ф S S S S S S S S 225 Commerce Drive, Fort Collins, Colorado 80524 TF: (800) 443-1511 PH: (870) 480-1511 FX: (870) 480-1522 15) 50- TPOZ - 01 MSD/W For metals or anions, please detail analytes below. **ALS Environmental** toby.leeson@stantec.com - 20 3 2103 Resort Dr. Suite 350 58-TPO7-01 Steamboat, CO 80487 58-7905-05 50-TPOY-05 53- TPO7-02 50-7104-06 58 - 7806 -01 Field ID ٢ 970-871-4361 Time Zone (Circle): EST CST MST PST 58 - Tpo7 7, Pog Toby Leeson St. Anthony 233001076 Stantec 5B -PHONE FAX PROJECT NAME SEND REPORT TO E-HAIL PROJECT No. COMPANY NAME **ADDRESS** ť, CITY / STATE / ZIP \_ ALS C ූ X Lab ID ブ T 

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							ILEVE	L III (Std OC + forms)
							LEVE IBW d	LL IV (Std QC + forms ata)
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eservative Key:	1-HCI	2-HNO3	3-H2SO4	4-NaOH	5-NaHSO4	7-Other	8-4 degree	кС 9-5035

	SIGNATURE	<b>ERUTED NAME</b>	DATE	TIME
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<b>ALS Envir</b>	225 Commerce Drive TF: (800) 443-1511 PH:			
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By Lab or Return to Client R (Souss) ð WORKORDER DISPOSAL PAGE Š torm 202rb OMTE 4 - 17 . 2018 ł Stal TURNAROUND Chain-of-Custody 226 (ANI NOT: 1.10) ъЯ > > > 8 Pres. ۸ 3325 S. Timberline Rd Suite 150 ¥ ¥ ¥ melanie.davis@stantec.com Bottes 3 Fort Collins, CO 80525 5 4.16.18/10:09 4.16.18 14:35 970-212-2749 Sample Time 4.16.18 14:30 Melanie Davis Breanna Van St. Anthony Stantec Sample Date BILL TO COMPANY INVOICE ATTN TO SAMPLER SITE ID **ADDRESS** CITY / STATE / ZIP PHONE FAX E-MAIL EDD FORMAT PURCHASE ORDER Matrix S S S S Fort Collins, Colorado 80524 (970) 480-1511 FX: (970) 490-1522 onmental toby.leeson@stantec.com 2103 Resort Dr. Suite 350 Steamboat, CO 80487 Field ID 5 B- TP0 8 . 02 SB-TPUB-0 58 · TP03 · DI 970-871-4361 Toby Leeson St. Anthony 233001076 Stantec PHONE Fě PROJECT NAME COMPANY NAME PROJECT No. SEND REPORT TO **ADDRESS** CITY / STATE / ZIP E-MAIL ALS Ó Leb D <u>ل</u>ے

XELL-JEAN SHIFTYAN 4117115 DATE RELINQUISHED BY BURLINNA JON BREANNA VAN PRINTED NAME SIGNATURE RECEIVED BY RECEIVED BY RELINQUISHED BY LEVEL III (Std QC + forms) LEVEL IV (Std QC + forms raw data) LEVEL II (Standard QC) CC PACKAGE (check below) For metals or anions, please detail analytes below. Comments:

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Matrix: O = oit S = soit NS = non-soit solid W = water L = liquid E = extract F = fitter

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1-HCI 2-HNO3 3-H2SO4 4-NaOH 5-NaHSO4 7-Other 8-4 degrees C 9-5035

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### ALS Environmental - Fort Collins CONDITION OF SAMPLE UPON RECEIPT FORM

(ALS)		<i>c</i> -		
Client: STANTZC-	Workorder No:	80452	1	
Project Manager:	Initials:	Date:	4.24	18_
Does this project require any special handling in addition to standard	ALS procedures?	Ò_	YES	NO
2. Are custody seals on shipping containers intact?		NONE)	YES	NO
3. Are Custody seals on sample containers intact?		NONE	YES	NO
4. Is there a COC (Chain-of-Custody) present or other representation	tive documents?		(YES)	, NO
5. Are the COC and bottle labels complete and legible?			YES	NO
6. Is the COC in agreement with samples received? (IDs, dates, ti of containers, matrix, requested analyses, etc.)	mes, no. of samples, r	ю.	YES	NO
7. Were airbills / shipping documents present and/or removable?		DROP OFF	YES	NO
8. Are all aqueous samples requiring preservation preserved correctly?	(excluding volatiles)	(N/A)	YES	NO
9. Are all aqueous non-preserved samples pH 4-9?		N/A	YES	NO
10. Is there sufficient sample for the requested analyses?		(YES)	NO	
11. Were all samples placed in the proper containers for the reque	YES	NO		
12. Are all samples within holding times for the requested analyse	YES	NO		
13. Were all sample containers received intact? (not broken or lea	king, etc.)		YES	NO
<sup>14.</sup> Are all samples requiring no headspace (VOC, GRO, RSK/MI headspace free? Size of bubble: < green pea	EE, Rx CN/S, radon) _> green pea	N/A	YES	NO
15. Do any water samples contain sediment?         Amount of sediment:	Amo	ount N/A	YES	NO
16. Were the samples shipped on ice?			YES	NO
<sup>17.</sup> Were cooler temperatures measured at 0.1-6.0°C? $\lim_{u \neq d^*:}$	#1 #3 ;	#4 QNLY	YES	NO
Cooler #:				
Temperature (°C): $fm(f)$				
No. of custody seals on cooler:				
DOT Survey/ Acceptance External μR/hr reading:				
Background $\mu$ R/hr reading: 7		<u> </u>		
Were external $\mu$ R/hr readings $\leq$ two times background and within DOT acceptance cri	teria? YES / NO / NA (1	(no, see Form 008)		
Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONS	E TO ANY QUESTION ABO	VE, EXCEPT #1 A	ND #16.	

\_ If applicable, was the client contacted? YES / NO / NA Contact: Date/Time: b Project Manager Signature / Date: 20

\*IR Gun #1, VWR SN 170560549 \*IR Gun #3, VWR SN 170647571 \*IR Gun #4, Oakton, SN 2372220101-0002

Page 1 of 6 of 22

1521 FROM: van SHIP DATE: 20APR18 ACTWGT: 30.00 LB CAD: 006993641/SSFE1904 DIMMED: 12 X 12 X 21 IN (103 60884 404-405-40350082 3325 s timberline rd ste 150 Fort Collins CO 80525 US ALS GROUP 225 COMMERCE DR 4 ç FORT COLLINS CO 80524 S DEP 1 V121115012601 uv 5 of 5 MPS# 7806 0754 0586 Mstr# 7806 0754 0542 80524 9622 0019 0 (000 000 0000) 0 00 7806 0754 0586

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# Gamma Spectroscopy Results PAI 713 Rev 14 Method Blank Results

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

l ah l	חו	GS180502-3MB
Lav	ID.	00100002 0100

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 29-Apr-18 Date Prepared: 29-Apr-18 Date Analyzed: 23-May-18 Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Run ID: GS180502-3A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 180566d05

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	-0.10 +/- 0.16	0.32	0.5	NA	U

### **Comments:**

### Qualifiers/Flags:

- U  $\,$  Result is less than the sample specific MDC or less than the associated TP
- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- M Requested MDC not met.
- B Analyte concentration greater than MDC.
- B3 Analyte concentration greater than MDC but less than Requested MDC.
- DL Decision Level

## Data Package ID: GSS1804521-1

Abbreviations:

TPU - Total Propagated Uncertainty

- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit

# **Gamma Spectroscopy Results**

PAI 713 Rev 14

Laboratory Control Sample(s)

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

### Lab ID: GS180502-3LCS

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 29-Apr-18 Date Prepared: 29-Apr-18 Date Analyzed: 23-May-18 Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Run ID: GS180502-3A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 180623d08

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Contro I Limits	Lab Qualifier
13982-63-3	Ra-226	449 +/- 53	2	468.3	95.9	85 - 115	P,M3

### **Comments:**

### Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP TPU - Total Propagated Uncertainty LT - Result is less than Requested MDC, greater than sample specific MDC. MDC - Minimum Detectable Concentration Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed. Y2 - Chemical Yield outside default limits. SQ - Spectral quality prevents accurate quantitation. L - LCS Recovery below lower control limit. SI - Nuclide identification and/or quantitation is tentative. H - LCS Recovery above upper control limit. TI - Nuclide identification is tentative. P - LCS Recovery within control limits. R - Nuclide has exceeded 8 halflives. M - The requested MDC was not met. M3 - The requested MDC was not met, but thereported activity is greater than the reported MDC.

### Data Package ID: GSS1804521-1

Abbreviations:

# **Gamma Spectroscopy Results**

PAI 713 Rev 14 Duplicate Sample Results (DER)

Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID: SI Lab ID: 18 Libr	eld ID:SB-TP07-01Sample Matrix: SOILPrep Batch: GS180502-3ab ID:1804521-1DUPPrep SOP: PAI 739 Rev 12QCBatchID: GS180502-3-1Library:RA226.LIBDate Collected: 16-Apr-18Run ID: GS180502-3ADate Analyzed: 29-Apr-18Count Time: 30 minutesDate Analyzed: 23-May-18Report Basis: Dry Weight		Batch: GS180502-3 tchID: GS180502-3-1 un ID: GS180502-3A Time: 30 minutes Basis: Dry Weight	Final Aliquot: 239 g Prep Basis: Dry Weight Moisture(%): NA Result Units: pCi/g File Name: 180702d02					
CASNO	Analyte	Sample Result +/- 2 s TPU	MDC	Flags	Dupli Result +/- 2 s TPU	cate MDC	Flags	DER	DER Lim
13982-63-3	Ra-226	29.3 +/- 3.5	0.9	M3	27.8 +/- 3.3	0.7	M3	0.296	2.13

### Comments:

Duplicate Qualifiers/Flags:		Abbreviations:
U - Result is less than the sample specific MDC.		TPU - Total Propagated Uncertainty
Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.		DER - Duplicate Error Ratio
Y2 - Chemical Yield outside default limits.		BDL - Below Detection Limit
W - DER is greater than Warning Limit of 1.42		NP - Not Poportod
D - DER is greater than Control Limit of 2.13		Nix - Nor Reported
LT - Result is less than Request MDC, greater than sample specific MDC		
M - Requested MDC not met.		
M3 - The requested MDC was not met, but the reported	SQ - Spectral quality prevents accurate quantitation.	
1 - LCS Recovery below lower control limit	SI - Nuclide identification and/or quantitation is tentative.	
H - LCS Recovery above upper control limit.	TI - Nuclide identification is tentative.	
P - LCS, Matrix Spike Recovery within control limits.	R - Nuclide has exceeded 8 halflives.	
N - Matrix Spike Recovery outside control limits	G - Sample density differs by more than 15% of LCS density.	

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP07-01           Lab ID:         1804521-1	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 16-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Run ID: GS180502-3A	Final Aliquot: 235 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180720d01

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	29.3 +/- 3.5	0.9	0.5	NA	M3

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

# **Gamma Spectroscopy Results**

PAI 713 Rev 14

Sample Duplicate Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:SB-THLab ID:18045	P07-01 521-1DUP	Prep Batch: GS180502-3           Prep SOP: PAI 739 Rev 12         QCBatchID: GS180502-3-1           Date Collected: 16-Apr-18         Run ID: GS180502-3A		Sample Matrix: SOIL         Prep Batch: GS180502-3         F           Prep SOP: PAI 739 Rev 12         QCBatchID: GS180502-3-1         F           Date Collected: 16-Apr-18         Run ID: GS180502-3A         F			Sample Matrix: SOILPrep Batch: GS180502-3Final AliquotPrep SOP: PAI 739 Rev 12QCBatchID: GS180502-3-1Prep BasisDate Collected: 16-Apr-18Run ID: GS180502-3AMoisture(%)			nal Aliquot: 239 Prep Basis: Dry	g Weight
Library	7: RA226.LIB	Date Prepared: 29-Apr-18 Date Analyzed: 23-May-18	Run ID: GS180502-3A Count Time: 30 minutes Report Basis: Dry Weight		Moisture(%): NA Result Units: pCi/g File Name: 180702d02						
040110	Towned Nevelide		МБО	Democrate	DI	Lak					

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	27.8 +/- 3.3	0.7	0.5	NA	M3

### **Comments:**

### Qualifiers/Flags:

- U Result is less than the sample specific MDC or less than the associated TPU.
- Y1 Chemical Yield is in control at 100-110%. Quantitative yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M The requested MDC was not met.
- M3 The requested MDC was not met, but thereported activity is greater than the reported MDC.
- W DER is greater than Warning Limit of 1.42
- D DER is greater than Control Limit of 2.13

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- **BDL** Below Detection Limit
- DL Decision Level

### Data Package ID: GSS1804521-1

### Date Printed:

Thursday, May 24, 2018

SQ - Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.

G - Sample density differs by more than 15% of LCS density.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

Page 1 of 1

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP07-201           Lab ID:         1804521-2	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 16-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Bun ID: GS180502-3A	Final Aliquot: 237 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 181118d04

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	27.8 +/- 3.4	1.1	0.5	NA	M3

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP07-02           Lab ID:         1804521-4	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 16-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Bun ID: GS180502-3A	Final Aliquot: 220 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180565d05

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.69 +/- 0.18	0.31	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP05-05           Lab ID:         1804521-5	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 16-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Run ID: GS180502-3A	Final Aliquot: 220 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180622d08

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.65 +/- 0.19	0.34	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP04-05           Lab ID:         1804521-6	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 16-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Bun ID: GS180502-34	Final Aliquot: 247 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Oriected: 10 Apr 10 Date Prepared: 29-Apr-18 Date Analyzed: 23-May-18	Count Time: 30 minutes Report Basis: Dry Weight	Result Units: pCi/g File Name: 180609d09
		Report Dation Bry Weight	

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	4.87 +/- 0.69	0.44	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

DL - Decision Level

## Data Package ID: GSS1804521-1

SI - Nuclide identification and/or quantitation is tentative. TI - Nuclide identification is tentative.

SQ - Spectral quality prevents accurate quantitation.

- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP04-06           Lab ID:         1804521-7	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 16-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Run ID: GS180502-3A	Final Aliquot: 218 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180624d10

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	2.79 +/- 0.39	0.33	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP06-01           Lab ID:         1804521-8	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 16-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Run ID: GS180502-3A	Final Aliquot: 195 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180914d03

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	4.79 +/- 0.71	0.67	0.5	NA	M3

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804521-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP09-02           Lab ID:         1804521-9	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 16-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Run ID: GS180502-3A	Final Aliquot: 206 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180709d07

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.54 +/- 0.32	0.47	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP08-01           Lab ID:         1804521-10	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 16-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Bun ID: GS180502-34	Final Aliquot: 220 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180721d01

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	15.3 +/- 1.9	0.7	0.5	NA	M3

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804521-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP08-02           Lab ID:         1804521-11	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1	Final Aliquot: 198 g Prep Basis: Dry Weight
Library: RA226.LIB	Date Collected: 16-Apr-18 Date Prepared: 29-Apr-18 Date Analyzed: 23-May-18	Count Time: 30 minutes Report Basis: Dry Weight	Result Units: pCi/g File Name: 180703d02

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.92 +/- 0.25	0.40	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804521-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804521

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP03-01           Lab ID:         1804521-12	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 16-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Bun ID: GS180502-3A	Final Aliquot: 204 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 181119d04

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.61 +/- 0.35	0.48	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
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- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804521-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.



# Gamma Spectroscopy Case Narrative

# Stantec

# St. Anthony Geotechnical Investigation – 233001076

Work Order Number: 1804517

- 1. The following report consists of analytical results for nine soil samples received by ALS on 04/24/2018.
- 2. These samples were prepared according to the current revision of SOP 739. The samples were sealed in steel cans on 05/02/2018 and stored for at least 21 days to allow <sup>222</sup>Rn to approach secular equilibrium with its parent, <sup>226</sup>Ra. The degree of ingrowth achieved prior to analysis on 05/23/2018 is at least 97.8%. Conservatively assuming a radon emanation efficiency of approximately 50%, the effective radon progeny ingrowth for these samples would be greater than 98.9%.
- 3. The samples were analyzed for the presence of gamma emitting radionuclides according to the current revision of SOP 713. The analyses were completed on 05/23/2018.
- 4. The results for these samples are reported on a "Dry Weight" basis in units of pCi/gram.
- 5. ALS has observed a reproducible low bias in <sup>226</sup>Ra results (about -30% for the geometry in question) when using a mixed gamma source for the calibration of HPGe detectors for solid samples. This bias is eliminated by calibration using a NIST traceable <sup>226</sup>Ra source in the same geometry and configuration as the samples.
- 6. The library used for calibration and analysis employs multiple peaks for the <sup>226</sup>Ra progeny, <sup>214</sup>Pb (352 and 295 keV) and <sup>214</sup>Bi (609 and 1120 keV). Using these peaks avoids the use of the problematic <sup>226</sup>Ra photopeak at 186 keV, which suffers from poorly resolvable interference from <sup>235</sup>U at the same energy. Final activity results for <sup>226</sup>Ra are calculated, using the uncertainty-weighted mean of the activities for the four photopeaks, by the Seeker gamma spectroscopy software assuming secular equilibrium.



- 7. There are cases where the sample density is less or greater than the associated calibration standard density. Cases that exceed the limit of +/- 15% of the density of the calibration standard are flagged with a 'G', denoting a significant density difference between the sample and calibration standard. Consequently, the results may be biased high for the flagged results where the sample density is less than the calibration density, and low for results where sample density is greater than the calibration density. If requested, ALS can perform a transmission spike in order to estimate a magnitude of this bias. The results are reported without further qualification.
- 8. The requested detection was not met for samples 18004517-3, -5, -6, and -8. The reported activity exceeds the achieved MDC. Results are submitted without further qualification. The results are flagged with an "M3" qualifier on the final reports.
- 9. No further problems were encountered with either the client samples or the associated quality control samples. All remaining quality control criteria were met.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

Pik Yee Yuen

Radiochemistry Primary Data Reviewer

stry Final Data Reviewer Radioche

5/24/18 Date

5/29/18 Date

# **ALS -- Fort Collins**

# Sample Number(s) Cross-Reference Table

OrderNum: 1804517 Client Name: Stantec Client Project Name: St. Anthony Geotechnical Investigation Client Project Number: 233001076 Client PO Number: 233001076

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
SB-TP21-01	1804517-1		SOIL	18-Apr-18	14:45
SB-TP21-02	1804517-2		SOIL	18-Apr-18	14:50
SB-TP11-04	1804517-3		SOIL	18-Apr-18	11:16
SB-TP11-05	1804517-4		SOIL	18-Apr-18	11:34
SB-TP12-03	1804517-5		SOIL	18-Apr-18	12:26
SB-TP12-04	1804517-6		SOIL	18-Apr-18	12:35
SB-TP14-02	1804517-7		SOIL	18-Apr-18	13:50
SB-TP14-202	1804517-8		SOIL	18-Apr-18	13:50
SB-TP14-03	1804517-10		SOIL	18-Apr-18	14:00

ALS Environment:	225 Commerce Drive, Fort Collins, Co
	anu ann

Chain\_of\_Custody

	ALS Environmental		•	Chain-of-C	ustody								(
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		PURCHABE ORDER				_							$\overline{}$
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SEND REPORT TO	Toby Leeson	INVOICE ATTN TO	Melanie Davis		יבג ייי								
ADDRESS	2103 Resort Dr. Suite 350	ADDRESS	3325 S. Timberline	Rd Suite 150	F) <u>2</u> 							$\overline{}$	
CITY / STATE / ZIP	Steamboat, CO 80487	CITY / STATE / ZIP	Fort Collins, CO 80	1525	010, 6		/						_
<b>INOHA</b>	970-871-4361	PHONE	970-212-2749		/ዓፖ								
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E-MAIL	toby.leeson@stantec.com	E-MAIL	melanie.davis@s	tantec.com	Dy I			_		<u> </u>			
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For metals or anior	ns, please detail analytes below.		<b>.</b>			NOB NOB	ATURE			ITED NAME	DATE		JWF
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### ALS Environmental - Fort Collins CONDITION OF SAMPLE UPON RECEIPT FORM

(ALS)	$\sim$				10		
Client:	STANTE	<u>.C</u>	Workord	ler No:	1300	517	_
Project Manager: _	L_2	S	_ 1	nitials:	<u> </u>	ate: 4-24	18
1. Does this project require	e any special handling	g in addition to stand	ard ALS proce	dures?	$\overline{)}$	YES	
2. Are custody seals on	shipping containers	intact?			NO	NE YES.	NO
3. Are Custody seals on	sample containers	intact?			NO	NE YES	NO
4 Is there a COC (Chai	n-of-Custody) prese	ent or other represe	ntative docur	nents?		YES	NO
5. Are the COC and bot	tle labels complete a	and legible?	····			YES	NO
<ol> <li>Is the COC in agreen of containers, matrix.</li> </ol>	nent with samples re , requested analyses.	cceived? (IDs, dates , etc.)	s, times, no. of	samples, no	).	YES	NO
7. Were airbills / shippi	ng documents prese	nt and/or removab	le?	·	DROP	OFF YES	NO
8. Are all aqueous sample	s requiring preservation	on preserved correctl	y? (excluding	volatiles)	THE	A YES	NO
9. Are all aqueous non-	preserved samples p	H 4-9?				A YES	NO
10. Is there sufficient sar	nple for the requeste	ed analyses?			$\sim$	YES	NO
11. Were all samples place	ced in the proper con	ntainers for the rec	uested analy	ses?		YES	NO
12. Are all samples withi	n holding times for	the requested analy	yses?			YES	NO
13. Were all sample cont	ainers received intac	et? (not broken or	leaking, etc.)	•		YES	NO
<sup>14.</sup> Are all samples requi headspace free?	ring no headspace ( Size of bubble:	VOC, GRO, RSK/ _ < green pea	MEE, Rx CN > green	/S, radon) pea	N/,	YES	NO
15. Do any water sample	s contain sediment?			Amo	unt		No
Amount of sediment:	dusting	moderate	heavy			A YES	NU
16. Were the samples shi	pped on ice?			· · · · · ·		YES	NO
<sup>17.</sup> Were cooler temperat	tures measured at 0.	1-6.0°C? IR gun used*:	#1	#3 #4	4 RA	D YES	NO
	Cooler #:						
	Temperature (°C):	AMB					
No. of cus	tody seals on cooler:		·				
DOT Survey/ Acceptance Ex	ternal µR/hr reading:	10					
Backg	round µR/hr reading:	$\overline{q}$	— <u> </u>				
Were external µR/hr readings	≤ two times background an	d within DOT acceptance	e criteria? YES	/NO/NA (If	no, see Form (	008.)	
Additional Information:	PROVIDE DETAILS BE	LOW FOR A NO RESPO	INSE TO ANY Q	UESTION ABO	VE, EXCEPT	#I AND #16.	
		· · · · · · · · · · · · · · · · · · ·					

If applicable, was the client contacted? YES / NO / NA Contact:

Project Manager Signature / Date: \_\_\_\_\_

h 4/26/18 \*IR Gun #1, VWR SN 170560549 \*IR Gun #3, VWR SN 170647571

Date/Time: \_\_\_\_\_

\*IR Gun #4, Oakton, SN 2372220101-0002

Page 1 of **5** of 17



# Gamma Spectroscopy Results PAI 713 Rev 14 Method Blank Results

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804517

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

l ah l	יחו	GS180502-3MB
Lau	ID.	0010002-0100

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 29-Apr-18 Date Prepared: 29-Apr-18 Date Analyzed: 23-May-18 Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Run ID: GS180502-3A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 180566d05

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	-0.10 +/- 0.16	0.32	0.5	NA	U

### **Comments:**

### Qualifiers/Flags:

- U  $\,$  Result is less than the sample specific MDC or less than the associated TP
- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- M Requested MDC not met.
- B Analyte concentration greater than MDC.
- B3 Analyte concentration greater than MDC but less than Requested MDC.
- DL Decision Level

## Data Package ID: GSS1804517-1

Abbreviations:

TPU - Total Propagated Uncertainty

- MDC Sample specific Minimum Detectable Concentration
- **BDL** Below Detection Limit

# **Gamma Spectroscopy Results**

PAI 713 Rev 14

Laboratory Control Sample(s)

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804517

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

### Lab ID: GS180502-3LCS

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 29-Apr-18 Date Prepared: 29-Apr-18 Date Analyzed: 23-May-18 Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Run ID: GS180502-3A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 180623d08

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Contro I Limits	Lab Qualifier
13982-63-3	Ra-226	449 +/- 53	2	468.3	95.9	85 - 115	P,M3

### **Comments:**

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP TPU - Total Propagated Uncertainty LT - Result is less than Requested MDC, greater than sample specific MDC. MDC - Minimum Detectable Concentration Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed. Y2 - Chemical Yield outside default limits. SQ - Spectral quality prevents accurate quantitation. L - LCS Recovery below lower control limit. SI - Nuclide identification and/or quantitation is tentative. H - LCS Recovery above upper control limit. TI - Nuclide identification is tentative. P - LCS Recovery within control limits. R - Nuclide has exceeded 8 halflives. M - The requested MDC was not met. M3 - The requested MDC was not met, but thereported activity is greater than the reported MDC.

### Data Package ID: GSS1804517-1

Abbreviations:

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804517

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP21-01           Lab ID:         1804517-1	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Bun ID: GS180502-34	Final Aliquot: 220 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180719d01

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.35 +/- 0.30	0.43	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804517-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804517

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP21-02           Lab ID:         1804517-2	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Bun ID: GS180502-3A	Final Aliquot: 212 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180701d02

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.78 +/- 0.22	0.37	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804517

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP11-04           Lab ID:         1804517-3	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Bun ID: GS180502-3A	Final Aliquot: 250 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 181117d04

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	21.7 +/- 2.7	0.9	0.5	NA	M3,G

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804517-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804517

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP11-05           Lab ID:         1804517-4	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Run ID: GS180502-3A	Final Aliquot: 192 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180564d05

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	4.30 +/- 0.61	0.44	0.5	NA	

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

DL - Decision Level

## Data Package ID: GSS1804517-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804517

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP12-03           Lab ID:         1804517-5	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Bun ID: GS180502-34	Final Aliquot: 180 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180621d08

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	2.25 +/- 0.42	0.52	0.5	NA	M3,G

## Comments:

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804517-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804517

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP12-04           Lab ID:         1804517-6	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Run ID: GS180502-3A	Final Aliquot: 245 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180608d09

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	16.0 +/- 2.0	0.6	0.5	NA	M3

### **Comments:**

### Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804517

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP14-02           Lab ID:         1804517-7	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Bun ID: GS180502-3A	Final Aliquot: 249 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180623d10

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	16.4 +/- 2.0	0.5	0.5	NA	G

### **Comments:**

### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804517-1

R - Nuclide has exceeded 8 halflives.

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804517

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP14-202           Lab ID:         1804517-8	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Run ID: GS180502-3A	Final Aliquot: 245 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180913d03

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	14.4 +/- 1.8	0.8	0.5	NA	M3

## Comments:

### Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

DL - Decision Level

## Data Package ID: GSS1804517-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1804517

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP14-03           Lab ID:         1804517-10	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180502-3 QCBatchID: GS180502-3-1 Bun ID: GS180502-3A	Final Aliquot: 189 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 23-May-18	Report Basis: Dry Weight	File Name: 180708d07

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	2.08 +/- 0.39	0.46	0.5	NA	

## Comments:

### Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

M - The requested MDC was not met.

### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

DL - Decision Level

## Data Package ID: GSS1804517-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.



# Gamma Spectroscopy Case Narrative

# Stantec

# St. Anthony Geotechnical Investigation – 233001076

## Work Order Number: 1804515

- 1. The following report consists of analytical results for 10 soil samples received by ALS on 04/24/2018.
- 2. These samples were prepared according to the current revision of SOP 739. The samples were sealed in steel cans on 04/30/2018 and stored for at least 21 days to allow <sup>222</sup>Rn to approach secular equilibrium with its parent, <sup>226</sup>Ra. The degree of ingrowth achieved prior to analysis on 05/21/2018 is at least 97.8%. Conservatively assuming a radon emanation efficiency of approximately 50%, the effective radon progeny ingrowth for these samples would be greater than 98.9%.
- 3. The samples were analyzed for the presence of gamma emitting radionuclides according to the current revision of SOP 713. The analyses were completed on 05/21/2018.
- 4. The results for these samples are reported on a "Dry Weight" basis in units of pCi/gram.
- 5. ALS has observed a reproducible low bias in <sup>226</sup>Ra results (about -30% for the geometry in question) when using a mixed gamma source for the calibration of HPGe detectors for solid samples. This bias is eliminated by calibration using a NIST traceable <sup>226</sup>Ra source in the same geometry and configuration as the samples.
- 6. The library used for calibration and analysis employs multiple peaks for the <sup>226</sup>Ra progeny, <sup>214</sup>Pb (352 and 295 keV) and <sup>214</sup>Bi (609 and 1120 keV). Using these peaks avoids the use of the problematic <sup>226</sup>Ra photopeak at 186 keV, which suffers from poorly resolvable interference from <sup>235</sup>U at the same energy. Final activity results for <sup>226</sup>Ra are calculated, using the uncertainty-weighted mean of the activities for the four photopeaks, by the Seeker gamma spectroscopy software assuming secular equilibrium.


- 7. There are cases where the sample density is greater than the associated calibration standard density. Cases that exceed the limit of +/- 15% of the density of the calibration standard are flagged with a 'G', denoting a significant density difference between the sample and calibration standard. Consequently, the results may be biased low for the flagged results in this work order. If requested, ALS can perform a transmission spike in order to estimate a magnitude of this bias. The results are reported without further qualification.
- 8. The requested detection limit was not met for samples 1804515-1, -2, -3, and -6. The reported activity exceeds the achieved MDC. Results are submitted without further qualification. The results are flagged with an "M3" qualifier on the final report.
- 9. No further problems were encountered with either the client samples or the associated quality control samples. All remaining quality control criteria were met.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

Pik Yee Yuen Radiochemistry Primary Data Reviewer

<u> 5/23/18</u> Date

Radiochemistry Final Data Reviewer

5/29/18 Date

# **ALS -- Fort Collins**

# Sample Number(s) Cross-Reference Table

OrderNum: 1804515 Client Name: Stantec Client Project Name: St. Anthony Geotechnical Investigation Client Project Number: 233001076 Client PO Number: 233001076

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
SB-TP02-01	1804515-1		SOIL	19-Apr-18	12:35
SB-TP02-02	1804515-2		SOIL	19-Apr-18	12:40
SB-TP01-01	1804515-3		SOIL	19-Apr-18	13:00
SB-TP01-02	1804515-4		SOIL	19-Apr-18	13:10
SB-TP18-01	1804515-5		SOIL	18-Apr-18	15:50
SB-TP18-02	1804515-6		SOIL	18-Apr-18	15:55
SB-TP17-01	1804515-7		SOIL	18-Apr-18	15:30
SB-TP17-02	1804515-8		SOIL	18-Apr-18	15:35
SB-TP16-01	1804515-9		SOIL	18-Apr-18	15:10
SB-TP16-02	1804515-10		SOIL	18-Apr-18	15:15

<b>ALS Environmei</b>	225 Commerce Drive, Fort Collins

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	<b>ALS Environmental</b>		Chain-of-Cus	stody				
	225 Commerce Drive, Fort Collins, Colorado 805; TF: (800) 443-1511 PH: (870) 490-1511 FX: (870) 490-	24 1522			Form 202rt			$\langle   \langle   \rangle$
(ALS)		SAMPLER	Breanna Van	DATE	4-19-15	PAGE	_	of 📕
PROJECT NAME	St. Anthony	STEID	St. Anthony	TURNAROUND	shandard	DISPOSAL	By Labor	Return to Clier
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COMPANY NAME	Stantec	BILL TO COMPANY	Stantec				-	
SEND REPORT TO	Toby Leeson	INVOICE ATTN TO	Melanie Davis					
ADDRE88	2103 Resort Dr. Suite 350	ADDRESS	3325 S. Timberline Rd Suite 150	пь				
CITY / STATE / 2P	Steamboat, CO 80487	CITY / STATE / ZP	Fort Collins, CO 80525	,) <i>o</i>				_
PHONE	970-871-4361	BHOHE	970-212-2749	77	_			
FAX		X		7 Ľ	/		<u>\</u>	
E-WAIL	toby.leeson@stantec.com	E-MAIL	melanie.davis@stantec.com	ਮੁ	/			
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e	Sh-T02-UI	s 4-6	7-18 12:35 1 NA					
$(\mathcal{I})$	SR-1002-02	s 4-1	9-18 12:40 1 NA	>				
(M	58-TP01-01	s 4-10	1-18 13: 00 1 NA	>				
(H)	SB-7P01-02	s 4-19	P16 13:10 1 NA				$\mathbf{k}$	
6	10-2107-BS	s  d-18	8-18 15:56 1 NA					
( ) )	SB. TP18-02	s 4-18	8-18 15:55 1 NA	$\checkmark$				
E	SB- 7P 17- 81	s 4-18	18 15:30 1 NA					
(8)	58-797-02	s 4-18	-16 15:35 1 NA	V     V				
(d)	SB-TP16-01	s 418	-18 15:10 1 NA					
Q	58-7916-02	s 413	AN 1 51:51 81-	<u> </u>				
Time Zone (Carcle): For metals or anic	EST CST MST PST Matrix 0 = oil S = s ons. please detail analytes below.	041 NS = non-soil soild W = V	water L = liquid E = extract F = hitter	BIGNATI		NTED NAME	DATE	BNL
Comments:		QC PACKAGE (chee		×				
	-		Standard QC)		M KELI	-JEAN CUI	1 24	1105
			(Sid QC + forms)	X				
-4		LEVEL IV rew data)	(Sid OC + forms +	)				
of			RELINQUISHED B	X				
Creaervative Key:	1-HCI 2-HNO3 3-H2SO4 4-NaOH 5-NaHS	04 7-Other 8-4 degrees C	9-5035	v				

ALS Environmental - Fort Collins CONDITION OF SAMPLE UPON RECEIPT FORM					
Client: STANTEC Workorder No: 15045	15				
Project Manager: LKS Initials: Date:	4.2.1.18				
1. Does this project require any special handling in addition to standard ALS procedures?	YES NO				
2. Are custody seals on shipping containers intact?	YES NO				
3. Are Custody seals on sample containers intact?	YES NO				
4. Is there a COC (Chain-of-Custody) present or other representative documents?	YES NO				
5. Are the COC and bottle labels complete and legible?	YES NO				
b. Is the COC in agreement with samples received? (IDs, dates, times, no. of samples, no. of containers, matrix, requested analyses, etc.)	YES NO				
7. Were airbills / shipping documents present and/or removable?	YES NO				
8. Are all aqueous samples requiring preservation preserved correctly? (excluding volatiles)	YES NO				
9. Are all aqueous non-preserved samples pH 4-9?	YESNO				
10. Is there sufficient sample for the requested analyses?					
11. Were all samples placed in the proper containers for the requested analyses?	YES NO				
12. Are all samples within holding times for the requested analyses?	YES NO				
13. Were all sample containers received intact? (not broken or leaking, etc.)	YES NO				
<sup>14.</sup> Are all samples requiring no headspace (VOC, GRO, RSK/MEE, Rx CN/S, radon) headspace free? Size of bubble: < green pea > green pea	YES NO				
15. Do any water samples contain sediment?       Amount         Amount of sediment:	YES NO				
16. Were the samples shipped on ice?	YES NO				
17. Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: #1 #3 #4 (RAD ONLY)	YES NO				
Cooler #: $\underline{AMB}$					
No. of custody seals on cooler:					
DOT Survey Acceptance External uR/br reading:					
Information Background uR/br reading: 9					
Were external uR/hr readings $\leq$ two times background and within DOT accordance with $r = 0$ (VES) (NO / NA / $r = 0$					
Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE, EXCEPT #1 A	ND #16.				

\*IR Gun #1, VWR SN 170560549 \*IR Gun #3, VWR SN 170647571 \*IR Gun #4, Oakton, SN 2372220101-0002



.

# Gamma Spectroscopy Results PAI 713 Rev 14 Method Blank Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1804515

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Lab ID: GS180501	1-1MB
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Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 29-Apr-18 Date Prepared: 29-Apr-18 Date Analyzed: 21-May-18 Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 180903d03

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.04 +/- 0.18	0.33	0.5	NA	U

## **Comments:**

#### Qualifiers/Flags:

- U  $\,$  Result is less than the sample specific MDC or less than the associated TP
- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- M Requested MDC not met.
- B Analyte concentration greater than MDC.
- B3 Analyte concentration greater than MDC but less than Requested MDC.
- DL Decision Level

## Data Package ID: GSS1804515-1

Abbreviations:

TPU - Total Propagated Uncertainty

- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit

# **Gamma Spectroscopy Results**

PAI 713 Rev 14

Laboratory Control Sample(s)

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804515

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

#### Lab ID: GS180501-1LCS

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 29-Apr-18 Date Prepared: 29-Apr-18 Date Analyzed: 21-May-18 Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 180700d07

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Contro I Limits	Lab Qualifier
13982-63-3	Ra-226	455 +/- 53	3	468.3	97.1	85 - 115	P,M3

## **Comments:**

#### Qualifiers/Flags:

 U
 - Result is less than the sample specific MDC or less than the associated TP
 TPU - Total Propagated Uncertainty

 L1
 - Result is less than Requested MDC, greater than sample specific MDC.
 MDC - Minimum Detectable Concentration

 Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
 Y2 - Chemical Yield outside default limits.
 SQ - Spectral quality prevents accurate quantitation.
 H

 L - LCS Recovery below lower control limit.
 SI - Nuclide identification and/or quantitation is tentative.
 H

 P - LCS Recovery within control limits.
 TI - Nuclide identification is tentative.
 H

 M - The requested MDC was not met.
 R - Nuclide has exceeded 8 halflives.
 H

 M3 - The requested MDC was not met, but thereported
 H
 H

## Data Package ID: GSS1804515-1

activity is greater than the reported MDC.

Abbreviations:

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804515

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP02-01           Lab ID:         1804515-1	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 239 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180612d10

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	35.4 +/- 4.2	0.6	0.5	NA	M3

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804515-1

- SQ Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804515

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP02-02           Lab ID:         1804515-2	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 205 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180708d01

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.38 +/- 0.32	0.51	0.5	NA	M3

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804515-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804515

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP01-01           Lab ID:         1804515-3	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 253 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180690d02

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	9.2 +/- 1.2	0.5	0.5	NA	M3,G

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804515-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804515

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Library: RA226.LIB Date Prepared: 29-Apr-18 Count Time: 30 minutes Result Units: pCi/g Date Analyzed: 21-May-18 Report Basis: Dry Weight File Name: 180902d03	Field ID:         SB-TP01-02           Lab ID:         1804515-4	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 206 g Prep Basis: Dry Weight Moisture(%): NA
Date Analyzed: 21-May-18 Report Basis: Dry Weight File Name: 180902d03	Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
		Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180902d03

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.26 +/- 0.30	0.50	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804515-1

TI - Nuclide identification is tentative.

SQ - Spectral quality prevents accurate quantitation.

SI - Nuclide identification and/or quantitation is tentative.

R - Nuclide has exceeded 8 halflives. G - Sample density differs by more than 15% of LCS density.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804515

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP18-01           Lab ID:         1804515-5	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 215 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180699d07

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.02 +/- 0.24	0.35	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804515-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804515

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP18-02           Lab ID:         1804515-6	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 214 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180599d09

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.94 +/- 0.27	0.50	0.5	NA	M3

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804515-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804515

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP17-01           Lab ID:         1804515-7	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 221 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180613d10

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.42 +/- 0.24	0.35	0.5	NA	

## Comments:

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804515-1

- SQ Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804515

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP17-02           Lab ID:         1804515-8	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 212 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 181111d04

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.91 +/- 0.26	0.41	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804515-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804515

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP16-01           Lab ID:         1804515-9	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Bun ID: GS180501-1A	Final Aliquot: 211 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180709d01

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.77 +/- 0.25	0.41	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804515-1

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804515

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP16-02           Lab ID:         1804515-10	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Bun ID: GS180501-14	Final Aliquot: 213 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180691d02

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.87 +/- 0.24	0.43	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804515-1

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.



# Gamma Spectroscopy Case Narrative

# Stantec

# St. Anthony Geotechnical Investigation – 233001076

## Work Order Number: 1804514

- 1. The following report consists of analytical results for nine soil samples received by ALS on 04/24/2018.
- 2. These samples were prepared according to the current revision of SOP 739. The samples were sealed in steel cans on 04/30/2018 and stored for at least 21 days to allow <sup>222</sup>Rn to approach secular equilibrium with its parent, <sup>226</sup>Ra. The degree of ingrowth achieved prior to analysis on 05/21/2018 is at least 97.8%. Conservatively assuming a radon emanation efficiency of approximately 50%, the effective radon progeny ingrowth for these samples would be greater than 98.9%.
- 3. The samples were analyzed for the presence of gamma emitting radionuclides according to the current revision of SOP 713. The analyses were completed on 05/21/2018.
- 4. The results for these samples are reported on a "Dry Weight" basis in units of pCi/gram.
- 5. ALS has observed a reproducible low bias in <sup>226</sup>Ra results (about -30% for the geometry in question) when using a mixed gamma source for the calibration of HPGe detectors for solid samples. This bias is eliminated by calibration using a NIST traceable <sup>226</sup>Ra source in the same geometry and configuration as the samples.
- 6. The library used for calibration and analysis employs multiple peaks for the <sup>226</sup>Ra progeny, <sup>214</sup>Pb (352 and 295 keV) and <sup>214</sup>Bi (609 and 1120 keV). Using these peaks avoids the use of the problematic <sup>226</sup>Ra photopeak at 186 keV, which suffers from poorly resolvable interference from <sup>235</sup>U at the same energy. Final activity results for <sup>226</sup>Ra are calculated, using the uncertainty-weighted mean of the activities for the four photopeaks, by the Seeker gamma spectroscopy software assuming secular equilibrium.



- 7. There are cases where the sample density is less than the associated calibration standard density. Cases that exceed the limit of +/- 15% of the density of the calibration standard are flagged with a 'G', denoting a significant density difference between the sample and calibration standard. Consequently, the results may be biased high for the flagged results in this work order. If requested, ALS can perform a transmission spike in order to estimate a magnitude of this bias. The results are reported without further qualification.
- 8. The requested detection limit was not met for samples 1804514-1, -2, -2DUP, -4, -7, -8, and -9. The reported activity exceeds the achieved MDC. Results are submitted without further qualification. The results are flagged with an "M3" qualifier on the final report.
- 9. No further problems were encountered with either the client samples or the associated quality control samples. All remaining quality control criteria were met.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

Pik Yee Yuen

Radiochemistry Primary Data Reviewer

Radiocy emistry Final Data Reviewer

<u>5/23/18</u> Date

5/29/18 Date

# **ALS -- Fort Collins**

# Sample Number(s) Cross-Reference Table

OrderNum: 1804514 Client Name: Stantec Client Project Name: St. Anthony Geotechnical Investigation Client Project Number: 233001076 Client PO Number: 233001076

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
SB-TP20-01	1804514-1		SOIL	19-Apr-18	11:33
SB-TP20-02	1804514-2		SOIL	19-Apr-18	11:40
SB-TP20-202	1804514-4		SOIL	19-Apr-18	11:40
SB-TP22-03	1804514-5		SOIL	19-Apr-18	9:00
SB-TP22-07	1804514-6		SOIL	19-Apr-18	9:25
SB-TP24-06	1804514-7		SOIL	19-Apr-18	11:17
SB-TP24-05	1804514-8		SOIL	19-Apr-18	11:06
SB-TP23-04	1804514-9		SOIL	19-Apr-18	10:10
SB-TP23-06	1804514-10		SOIL	19-Apr-18	10:20

<b>ALS Environmental</b>	225 Commerce Drive, Fort Collins, Colora
$\leftarrow$	100

Chain-of-Custody

					1stouy		WORKORDER		
	Z25 Commerce Drive, Fort Collins, Colorado 80524 TF: (800) 443-1511 PH: (970) 490-1511 FX: (970) 490-15;	7				Form 202r6	•	1909	77
(ALS)	•	SAMPLER	Breanna Van		- p1-d-ld-	18	PAGE	l of	-
PROJECT NAME	St. Anthony	STEID	St. Anthony		TURNAROUND SHOL	pubb	DISPOSAL	By Labor R	eturn to Client
PROJECT No.	233001076	EDD FORMAT			Por series and series				
	*	PURCHASE ORDER							~
COMPANY NAME	Stantec	BILL TO COMPANY	Stantec		2				
SEND REPORT TO	Toby Leeson	INVOICE ATTN TO	Melanie Davis		17				
ADDRESS	2103 Resort Dr. Suite 350	ADDRESS	3325 S. Timberline	e Rd Suite 150					
CITY / STATE / ZIP	Steamboat, CO 80487	CITY / STATE / ZIP	Fort Collins, CO 8	30525	,7°				
PHONE	970-871-4361	HOHA	970-212-2749		7			<u> </u>	
FAX		FAX			.2	_			
EMAIL	toby.leeson@stantec.com	E-MAIL	melanie.davis@	stantec.com	by	2			
9	· •	Autor Matrix Ser	npie Sampie ato Time	ž					
				6			$\mathbf{X}$		
9	58-7020-01	s 4-	9-18 11:33	AN I			W W	ļ	
$\left( 2\right)$	58.1920-02	s  4-1	9-18 11:40	I NA					
11232	JS. B. TP2U - U2 MSMSD	s Alo	1-18 11:40	AN 1					
6	5.8-7720-202	s 4-1	9-18 11:40	l NA		$ \Lambda $			
G	SB-TP22-03	s 4-1(	9-16 9:00	) NA				$\boldsymbol{\Lambda}$	
9	5B-TP22-07	s 41	9-16 9:25	AN (					
Ð	SB-TP24-010	s 4-1	7-18 11:17	AN I	$ \Lambda $				
Ì	58-TP24-05	s 4-10	1-18 11:00	H NA					
6	SD- 7P23-04	s 4-10	7-18 10:10	AN I					2
9	5B-7P23-0 Le	s 4-10	7-18 10:20	AN 1					
"Time Zo <del>ne (</del> Circle): For metals or anic	EST CST MST PST Matrix: O = oil S = soil ons. blease detail analytes below.	NS = non-soil solid W =	water L = liquid E = extr	ract F = fitter	SIGNATIRE	Nilla	TED NAUF	E A	- ANE
Commonde:		ACT BACKAGE (*)							
		I FEVEL 1	(Standard QC)	RECEIVED		T XELT	-JEAN SM	31. hc. hall	1205
			(Std OC + forms)	RELINQUISHED	K As				
		LEVEL N raw data)	/ (Std QC + forms +	RECEIVED	BY				
Fof				RELINQUISHED				-	
Preservative Key:	1-HCI 2-HNO3 3-H2SO4 4-NaOH 5-NaHSO4	7-Other 8-4 degrees (	5 9-5035	RECEIVE	BY				

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ALS Environmental - Fort Collins	
ONDITION OF CAMPLE UDON DECEMBER	•

CONDITION OF SAMPLE UPON RECEIPT FORM	
(ALS) Client: STANTEC Workorder No: 1804	YE
Project Manager: LRS Initials: Date	4.24.18
1. Does this project require any special handling in addition to standard ALS procedures?	YES (NO)
2. Are custody seals on shipping containers intact?	YES NO
3. Are Custody seals on sample containers intact?	YES NO
4. Is there a COC (Chain-of-Custody) present or other representative documents?	YES NO
5. Are the COC and bottle labels complete and legible?	(YES) NO
6. Is the COC in agreement with samples received? (IDs, dates, times, no. of samples, no. of containers, matrix, requested analyses, etc.)	YES NO
7. Were airbills / shipping documents present and/or removable?	YES NO
8. Are all aqueous samples requiring preservation preserved correctly? (excluding volatiles)	YES NO
9. Are all aqueous non-preserved samples pH 4-9?	YES NO
10. Is there sufficient sample for the requested analyses?	YES NO
11. Were all samples placed in the proper containers for the requested analyses?	YES NO
12. Are all samples within holding times for the requested analyses?	NO
13. Were all sample containers received intact? (not broken or leaking, etc.)	YES NO
<sup>14.</sup> Are all samples requiring no headspace (VOC, GRO, RSK/MEE, Rx CN/S, radon) headspace free? Size of bubble: < green pea > green pea	YES NO
15. Do any water samples contain sediment? Amount	
Amount of sediment: dusting moderate heavy	YES NO
16. Were the samples shipped on ice?	YES NO.
17. Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: #1 #3 #4 ONLY	YES NO
Cooler #: Temperature (°C): <u>AMUB</u> No. of custody seals on cooler: <u>O</u> DOT Survey Acceptance Information External µR/hr reading: <u>IO</u> Background µR/hr reading: <u>IO</u> Were external µR/hr reading: <u>IO</u> Were external µR/hr reading: <u>IO</u> Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANX QUESTION ABOVE, EXCEPT #1 /	) AND #16.
If applicable, was the client contacted? YES / NO / NA Contact: Date/T Project Manager Signature / Date:	ime:

\*IR Gun #1, VWR SN 170560549 \*IR Gun #3, VWR SN 170647571 \*IR Gun #4, Oakton, SN 2372220101-0002

Page 1 of **5 of 19** 



# Gamma Spectroscopy Results PAI 713 Rev 14 Method Blank Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

l ah	יחו	GS180501-1MB
LUD		

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 29-Apr-18 Date Prepared: 29-Apr-18 Date Analyzed: 21-May-18 Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 180903d03

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.04 +/- 0.18	0.33	0.5	NA	U

## **Comments:**

#### Qualifiers/Flags:

- U  $\,$  Result is less than the sample specific MDC or less than the associated TP
- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- M Requested MDC not met.
- B Analyte concentration greater than MDC.
- B3 Analyte concentration greater than MDC but less than Requested MDC.
- DL Decision Level

## Data Package ID: GSS1804514-1

- Abbreviations:
- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- **BDL** Below Detection Limit

# **Gamma Spectroscopy Results**

PAI 713 Rev 14

Laboratory Control Sample(s)

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

#### Lab ID: GS180501-1LCS

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 29-Apr-18 Date Prepared: 29-Apr-18 Date Analyzed: 21-May-18 Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 180700d07

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Contro I Limits	Lab Qualifier
13982-63-3	Ra-226	455 +/- 53	3	468.3	97.1	85 - 115	P,M3

## **Comments:**

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP TPU - Total Propagated Uncertainty LT - Result is less than Requested MDC, greater than sample specific MDC. MDC - Minimum Detectable Concentration Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed. Y2 - Chemical Yield outside default limits. SQ - Spectral quality prevents accurate quantitation. L - LCS Recovery below lower control limit. SI - Nuclide identification and/or quantitation is tentative. H - LCS Recovery above upper control limit. TI - Nuclide identification is tentative. P - LCS Recovery within control limits. R - Nuclide has exceeded 8 halflives. M - The requested MDC was not met. M3 - The requested MDC was not met, but thereported activity is greater than the reported MDC.

## Data Package ID: GSS1804514-1

Abbreviations:

# **Gamma Spectroscopy Results**

PAI 713 Rev 14 Duplicate Sample Results (DER)

Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:SB-TP20-02Lab ID:1804514-2DUPLibrary:RA226.LIB		Sample Matrix: SOIL Prep SOP: PAI 739 Date Collected: 19-Apr- Date Prepared: 29-Apr- Date Analyzed: 21-May	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18 Date Prepared: 29-Apr-18 Date Analyzed: 21-May-18		Batch: GS180501-1 IcchID: GS180501-1-1 un ID: GS180501-1A Time: 30 minutes Basis: Dry Weight	Final Aliquot: 190 g Prep Basis: Dry Weigh Moisture(%): NA Result Units: pCi/g File Name: 180900d0		ght 03	
CASNO	Analyte	Sample Result +/- 2 s TPU	e MDC	Flags	Dupli Result +/- 2 s TPU	cate MDC	Flags	DER	DER Lim
13982-63-3	Ra-226	1 32 +/- 0 32	0.54	M3 G 1 09 ±/- 0 31		0.52 M3		0.504	2 13

## Comments:

Duplicate Qualifiers/Flags:		Abbreviations:
U - Result is less than the sample specific MDC.		TPU - Total Propagated Uncertainty
Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.		DER - Duplicate Error Ratio
Y2 - Chemical Yield outside default limits.		BDL - Below Detection Limit
W - DER is greater than Warning Limit of 1.42		NR - Not Reported
D - DER is greater than Control Limit of 2.13		
LT - Result is less than Request MDC, greater than sample specific MDC		
M - Requested MDC not met.		
M3 - The requested MDC was not met, but the reported	SQ - Spectral quality prevents accurate quantitation.	
L - LCS Recovery below lower control limit.	SI - Nuclide identification and/or quantitation is tentative.	
H - LCS Recovery above upper control limit.	TI - Nuclide identification is tentative.	
P - LCS, Matrix Spike Recovery within control limits.	R - Nuclide has exceeded 8 halflives.	
N - Matrix Spike Recovery outside control limits	G - Sample density differs by more than 15% of LCS density.	

## Data Package ID: GSS1804514-1

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP20-01           Lab ID:         1804514-1	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 167 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180706d01

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.60 +/- 0.38	0.58	0.5	NA	M3,G

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

DL - Decision Level

## Data Package ID: GSS1804514-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP20-02           Lab ID:         1804514-2	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 183 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180688d02

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.32 +/- 0.32	0.54	0.5	NA	M3,G

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804514-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

# **Gamma Spectroscopy Results**

PAI 713 Rev 14

Sample Duplicate Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:SB-TRLab ID:18045	P20-02	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS QCBatchID: GS Run ID: GS	S180501-1	Final Aliquot: 190 Prep Basis: Dry Moisture(%): NA	g Weight
Library	RA226.LIB	Date Prepared: 29-Apr-18 Date Analyzed: 21-May-18	Count Time: 30 Report Basis: Dr	minutes y Weight	Result Units: pCi File Name: 180	/g 900d03
	- (N 01				. 51	

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.09 +/- 0.31	0.52	0.5	NA	M3

## Comments:

## Qualifiers/Flags:

- U Result is less than the sample specific MDC or less than the associated TPU.
- Y1 Chemical Yield is in control at 100-110%. Quantitative yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.

M - The requested MDC was not met.

- M3 The requested MDC was not met, but thereported activity is greater than the reported MDC.
- W DER is greater than Warning Limit of 1.42
- D DER is greater than Control Limit of 2.13

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- **BDL** Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804514-1

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP20-202           Lab ID:         1804514-4	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 189 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180597d09

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.26 +/- 0.34	0.61	0.5	NA	M3

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804514-1

SQ - Spectral quality prevents accurate quantitation.

- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP22-03           Lab ID:         1804514-5	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 230 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180611d10

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	6.63 +/- 0.85	0.38	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804514-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP22-07           Lab ID:         1804514-6	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Bun ID: GS180501-1A	Final Aliquot: 223 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180698d07

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.97 +/- 0.35	0.42	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804514-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP24-06           Lab ID:         1804514-7	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 211 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180707d01

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	55.5 +/- 6.6	1.0	0.5	NA	M3

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804514-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP24-05           Lab ID:         1804514-8	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 225 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180689d02

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	30.0 +/- 3.6	0.8	0.5	NA	M3

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804514-1

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP23-04           Lab ID:         1804514-9	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 245 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180901d03

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	31.2 +/- 3.8	0.9	0.5	NA	M3

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804514-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

## Lab Name: ALS -- Fort Collins

Work Order Number: 1804514

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SB-TP23-06           Lab ID:         1804514-10	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 19-Apr-18	Prep Batch: GS180501-1 QCBatchID: GS180501-1-1 Run ID: GS180501-1A	Final Aliquot: 218 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 29-Apr-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 21-May-18	Report Basis: Dry Weight	File Name: 180598d09

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	2.26 +/- 0.40	0.48	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1804514-1

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.
## Appendix C St. Anthony Mine Site Correlation Data (Gamma Radiation Level to Ra-226 Correlation Regression Analysis Static Gamma Radiation Survey Field Forms for Correlations Field Soil Sample Log Forms Correlation Soil Sample Laboratory Analytical Result Reports)

## AVM Environmental Services, Inc. Gamma Radiation Survey @ St. Anthony Mine Site Static Gamma Radiation Survey Field Form For Correlation

Instrumentation : Scaler/Ratemeter 222/ \$#290801, Detector SPA-3 #33 8-1-17 Instrument Calibration Date: , Instrument Daily Function Check Performed: St. Anthony Correlation Survey Area/Unit Decsription

	Survey Point & Soil	Survey Poir (State Plain,	nt Coordinate , NAD 1983)	Gamma Rad SPA-3, SR	Level (cpm) 408522-33	uR/hr	
Survey Date	Sample ID/Description	Northing (ft)	Easting (ft)	Lead Collimated	Bare		Comments/Notes
5-7-18	SS-COR-001	1517823.1	2878759.2	3324 3383 3381	9937 10077 10013	10	
11	SS-COR-002	1517808.0	2878713.9	3165	10406 10441 10425	11	
11	SS-COR-003	1518535.2	2880210.2	25600 25894 25731	84039 83117 83189	95	Park goes Material in better hilf of Somek layer
11	55-COR-004	1517269.8	2879341.7	22796 20739 22490	68362 64884 65222	70	
19	55-COR-005	1517373.8	2879448.8	7439 6924 7043	19346 19412 19769	20	
11	55-COR-006	1517565.3	2878649.3	3124 3328 3251	11405 11685	12	
11	55-cor-007	1516883.8	2880235.5	4991 5241 5096	14131 14174 14372	15	
11	55-COR-008	1516845.4	2880218.5	6891 6849 7065	20219 20268 20155	20	
1)	SS-COR-009	1516767.1	2880261.7	26362 26596 26725	64037 64428 63871	70	
1	55-cor-010	15168560	28803152	8575 8672 18635	22943 23060 22997	25	
Technician Signa	ture Notfiel	5 ,R	eviewed by	The			

## AVM Environmental Services, Inc. Gamma Radiation Survey @ St. Anthony Mine Site Static Gamma Radiation Survey Field Form For Correlation

Instrumentation : Scaler/Ratemeter 12221 5#290801, Detector SPA-3 #33 8-1-17 Instrument Calibration Date: , Instrument Daily Function Check Performed: Correlation St. Anthony Survey Area/Unit Decsription \_

	Survey Point & Soil	Survey Poin (State Plain,	t Coordinate NAD 1983)	Gamma Rad SPA-3, SR	Level (cpm) # 408522-33	uR/hr	
Survey Date	Sample ID/Description	Northing (ft)	Easting (ft)	Lead Collimated	Bare		Comments/Notes
5-7-18	SS-COR-OII	1513846.9	2881467.5	35912 36235 35798	99965 96941 98212	110	f berns nearby
11	SS-COR-012	1513530.4	2884936.9	7748 8050 8126	25242 25514 25390	30	
11	55-COR-013	1513563.9	2884900.3	8293 8192 8199	21581 21295 21891	25	
11	SS-COR-014	1517657.2	2879464.5	4358 4412 4496	11945 11972 11970	12	
					•		
						-	
				7			
				1			

#### AVM Environmental Services, Inc. Field Soil Sample Log Form St. Anthony Mine Site

Sample ID	Sample Date and Time	Sample Location (Coordinates)	Sample collection method/container/preservative	Analysis	Sample Type/Description	Comments/Notes	Sample Tech
55-COR-001	5-7-18 C 838	y1517823.1 ×2878759.2	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab		NP
\$5- (0R-002	57-18 C 852	y 1517808.0 x 2878713.9	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab		VP
55-COR-003	5-7-18 C915	y 1518535.2 x 2880210.2	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab	55 cor-203 5-7-18 20930	NP
55-COR-004	5-7-18 C <b>9</b> 55	y 1517269.8 x 2879341.7	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab		VP
SS-COR-005	5-7-18 C1035	y1517373.8 x 2879448.8	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab		VP
55-COR -006	5-7-18 @ 1105	y 1517565.3 X 28786493	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab	Field QA/QC Dup. SS-COR-2016 5-7-18 @ 1120	VP
SS-COR-007	5-7-18 @ 1155	y 1516883.8 x 2880235.5	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab		VP
55-CoR-008	5-7-18 @1205	y 1516845.4 ×2880218.5	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab		VP
55-COR-009	5-7.18 C1:225	У1516767.1 X 2880261.7	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab		VP
55-COR-010	5-7-18 C1235	У 15168560 X 2880315,2	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab		NP
SS-COR-OII	5-7-18 @1325	y 15138469 X 2881467.5	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab		VF
55-COR-012	5-7-18 @1410	Y 1513530.4 X 2884936.9	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab		v٩

Please include other applicable information, such as sampling activity/event, COC#, sampling depth, soil description, sample sub-location, etc in sample description or comments/notes

#### AVM Environmental Services, Inc. Field Soil Sample Log Form St. Anthony Mine Site

Sample ID	Sample Date and Time	Sample Location (Coordinates)	Sample collection method/container/preservative	Analysis	Sample Type/Description	Comments/Notes	Sample Tech
SS-COR-013	5-7-18 C1420	Y 151356309 X 2884900.3	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab		VP
SS-COR-OI4	5-7-18 @1535	у 151 <b>9</b> 657.2 x 28 <sup>-</sup> 79464.5	Hand Auger/Hand Spade Plastic Bag No Preservative	Ra-226	Correlation Surface Soil/Grab		VP
•							

Please include other applicable information, such as sampling activity/event, COC#, sampling depth, soil description, sample sub-location, etc in sample description or comments/notes

#### Gamma Radiation Level to Soil Ra-226 Concentration Correlation St. Anthony Mine Site 2x2 Nal Bare Detector (SPA-3)

Surface Soil Sample ID	2x2 Nal Bare Detector CPM	Ra-226 pCi/g	Predicted Ra- 226 pCi/g	е	e^2
SA-COR-001	10009	0.85	-0.51	1.36	1.84
SA-COR-002	10424	0.83	-0.30	1.13	1.27
SA-COR-003	83615	43.90	36.30	7.60	57.80
SA-COR-004	66156	25.30	27.57	-2.27	5.14
SA-COR-005	19509	6.36	4.24	2.12	4.48
SA-COR-006	11428	0.75	0.20	0.55	0.30
SA-COR-007	14226	2.73	1.60	1.13	1.27
SA-COR-008	20214	5.17	4.60	0.57	0.33
SA-COR-009	64112	29.70	26.55	3.15	9.95
SA-COR-010	23000	6.78	5.99	0.79	0.62
SA-COR-012	25382	6.63	7.18	-0.55	0.30
SA-COR-013	21589	5.45	5.28	0.17	0.03
SA-COR-014	11962	1.25	0.47	0.78	0.61
			Mean	1.27	6.46



#### REGRESSION SUMMARY OUTPUT

Regression Statistics					
Multiple R	0.988945607				
R Square	0.978013413				
Adjusted R Square	0.976014633				
Standard Error	2.111552191				
Observations	13				

#### ANOVA

	df	SS	MS	F	Significance F
Regression	1	2181.64119	2181.64119	489.3050341	1.80856E-10
Residual	11	49.04517922	4.458652656		
Total	12	2230.686369			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-5.512824494	0.928968951	-5.934347414	9.81159E-05	-7.557471369	-3.46817762	-7.557471369	-3.46817762
X Variable 1	0.000543377	2.45647E-05	22.12024037	1.80856E-10	0.00048931	0.000597443	0.00048931	0.000597443

#### Gamma Radiation Level to Soil Ra-226 Concentration Correlation St. Anthony Mine Site 0.5 Inch Thick Lead Collimated 2x2 Nal Detector (SPA-3)

Surface Soil Sample ID	2x2 Nal Bare Detector CPM	Ra-226 pCi/g	Predicted Ra- 226 pCi/g	е	e^2
SA-COR-001	3363	0.85	-0.17	1.02	1.03
SA-COR-002	3158	0.83	-0.47	1.30	1.70
SA-COR-003	25742	43.90	33.40	10.50	110.20
SA-COR-004	22008	25.30	27.80	-2.50	6.26
SA-COR-005	7135	6.36	5.49	0.87	0.75
SA-COR-006	3234	0.75	-0.36	1.11	1.23
SA-COR-007	5109	2.73	2.45	0.28	0.08
SA-COR-008	6932	5.17	5.19	-0.02	0.00
SA-COR-009	26561	29.70	34.63	-4.93	24.32
SA-COR-010	8607	6.78	7.70	-0.92	0.85
SA-COR-012	7975	6.63	6.75	-0.12	0.01
SA-COR-013	8228	5.45	7.13	-1.68	2.83
SA-COR-014	4422	1.25	1.42	-0.17	0.03
			Mean	0.36	11.48



#### SUMMARY OUTPUT

Regression Statistics						
Multiple R	0.966609815					
R Square	0.934334535					
Adjusted R Square	0.928364948					
Standard Error	3.649147559					
Observations	13					

#### ANOVA

	df	SS	MS	F	Significance F
Regression	1	2084.207312	2084.207312	156.5157566	7.57125E-08
Residual	11	146.479057	13.31627791		
Total	12	2230.686369			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-5.206105492	1.608752692	-3.236112995	0.007928568	-8.746946291	-1.665264693	-8.746946291	-1.66526469
X Variable 1	0.00153524	0.000122715	12.51062575	7.57125E-08	0.001265146	0.001805334	0.001265146	0.00180533

#### Gamma Exposure Rate to Soil Ra-226 Concentration Correlation St. Anthony Mine Site Ludium 19 Micro R meter

Surface Soil Sample ID	Exposure Rate Ludlum 19	Ra-226 pCi/g	Predicted Ra- 226 pCi/g	е	e^2
SA-COR-001	10	0.85	-0.2	1.05	1.10
SA-COR-002	11	0.83	0.3	0.54	0.29
SA-COR-003	95	43.90	41.5	2.45	6.00
SA-COR-004	70	25.30	29.2	-3.90	15.21
SA-COR-005	20	6.36	4.7	1.66	2.76
SA-COR-006	12	0.75	0.8	-0.03	0.00
SA-COR-007	15	2.73	2.3	0.48	0.23
SA-COR-008	20	5.17	4.7	0.47	0.22
SA-COR-009	70	29.70	29.2	0.50	0.25
SA-COR-010	25	6.78	7.2	-0.37	0.14
SA-COR-012	30	6.63	9.6	-2.97	8.82
SA-COR-013	25	5.45	7.2	-1.70	2.89
SA-COR-014	12	1.25	0.8	0.47	0.22
			Mean	-0.10	2.93



#### SUMMARY OUTPUT

Regression	Statistics
Multiple R	0.991471657
R Square	0.983016046
Adjusted R Square	0.981472051
Standard Error	1.855847609
Observations	13

#### ANOVA

	df	SS	MS	F	Significance F
Regression	1	2192.800495	2192.800495	636.6701629	4.36259E-11
Residual	11	37.88587381	3.444170346		
Total	12	2230.686369			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-5.095319041	0.802456682	-6.349649965	5.4476E-05	-6.861514288	-3.329123794	-6.861514288	-3.329123794
X Variable 1	0.486600356	0.019284802	25.23232377	4.36259E-11	0.444154794	0.529045917	0.444154794	0.529045917



# Gamma Spectroscopy Case Narrative

# **Stantec Consulting Services**

St. Anthony - 233001076

Work Order Number: 1807040

- 1. The following report consists of analytical results for eight soil samples received by ALS on 07/05/2018.
- 2. These samples were prepared according to the current revision of SOP 739. The samples were sealed in steel cans on 07/18/2018 and stored for at least 21 days to allow <sup>222</sup>Rn to approach secular equilibrium with its parent, <sup>226</sup>Ra. The degree of ingrowth achieved prior to analysis on 08/08/2018 is at least 97.8%. Conservatively assuming a radon emanation efficiency of approximately 50%, the effective radon progeny ingrowth for these samples would be greater than 98.9%.
- 3. The samples were analyzed for the presence of gamma emitting radionuclides according to the current revision of SOP 713. The analyses were completed on 08/08/2018.
- 4. The results for these samples are reported on a "Dry Weight" basis in units of pCi/gram. The samples were not crushed or sieved before can packing.
- 5. ALS has observed a reproducible low bias in <sup>226</sup>Ra results (about -30% for the geometry in question) when using a mixed gamma source for the calibration of HPGe detectors for solid samples. This bias is eliminated by calibration using a NIST traceable <sup>226</sup>Ra source in the same geometry and configuration as the samples.
- 6. The library used for calibration and analysis employs multiple peaks for the <sup>226</sup>Ra progeny, <sup>214</sup>Pb (352 and 295 keV) and <sup>214</sup>Bi (609 and 1120 keV). Using these peaks avoids the use of the problematic <sup>226</sup>Ra photopeak at 186 keV, which suffers from poorly resolvable interference from <sup>235</sup>U at the same energy. Final activity results for <sup>226</sup>Ra are calculated, using the uncertainty-weighted mean of the activities for the four photopeaks, by the Seeker gamma spectroscopy software assuming secular equilibrium.



- 7. The requested detection limit was not met for samples 1807040-1, -2, -5, -6, and -7DUP. The reported activity for these samples exceeds the achieved MDC. Results are submitted without further qualification. The results are identified with an "M3" qualifier on the final reports.
- 8. No further problems were encountered with either the client samples or the associated quality control samples. All remaining quality control criteria were met.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

Jean Anderson

Radiochemistry Frimary Data Reviewer

Radioc emistry Final Data Reviewer

<u>8/9/18</u> Date

<u>8/10/18</u> Date

2 of 18

# **ALS -- Fort Collins**

## Sample Number(s) Cross-Reference Table

OrderNum: 1807040 Client Name: Stantec Consulting Services Client Project Name: St. Anthony Client Project Number: 233001076 Client PO Number: 233001076-ALS2

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
SS-COR-004	1807040-1		SOIL	07-May-18	9:55
SS-COR-005	1807040-2		SOIL	07-May-18	10:35
SS-COR-007	1807040-3		SOIL	07-May-18	11:55
SS-COR-008	1807040-4		SOIL	07-May-18	12:05
SS-COR-009	1807040-5		SOIL	07-May-18	12:25
SS-COR-010	1807040-6		SOIL	07-May-18	12:35
SS-COR-012	1807040-7		SOIL	07-May-18	14:10
SS-COR-013	1807040-8		SOIL	07-May-18	14:20

<b>ALS Environ</b>	225 Commerce Drive, Fort (

	<b>ALS Environmental</b>			-	Chain-	of-Cust	ody					
	225 Commerce Drive, Fort Collins, Colorado 80524 TF: (800) 443-1511 PH: (870) 490-1511 FX: (870) 480-152	2							Form 202rB	*	18070	Q
(ALS)		SAMP	LER Victor					DATE 7/2/2018		PAGE	1 of	-
PROJECT NAME	St. Anthony	5	TEID St. A	nthony	:		TURNA	ROUND Standard		DISPOSAL B	ly Labor Ret	urn to Client
PROJECT No.	233001076	EDD FOR	MAT									
		PURCHASE OR	<b>DER</b>									
COMPANY NAME	Stantec	BILL TO COMP	ANY Stant	ec			(					
SEND REPORT TO	Toby Leeson	INVOICE ATT	N TO Melai	nie Davis			bəiti					
ADDRESS	2103 Resort Dr. Suite 350	ADDR	<b>LESS</b> 3325	S. Timberline	Rd Suite	150	pow					
CITY / STATE / ZIP	Steamboat, CO 80487	CITY / STATE	ZIP Fort (	Collins, CO 8	<b>525</b>		1.10					
BHONE	970-871-4361	Hd	<b>ONE</b> 970	F212-2749			D6) 9					
FAX			FAX				52					· .
E-WAIL	toby.leeson@stantec.com	Ш	<b>LAIL</b> mel	anie.davis@s	stantec.cor		я В					
<b>D</b>	L D D D D D D D D D D D D D D D D D D D	Match	Sample Date	Sample Time	ے (2)	8						
C	SS-COR-004	s	5/7/2018	0955	-	4	5					
(2)	SS-COR-005	S	5/7/2018	1035	-	Ă						
(m)	SS-COR-007	s	5/7/2018	1155	-	A N						
E.	SS-COR-008	s	5/7/2018	1205	-	٨A						-
$\Sigma$	SS-COR-009	s	5/7/2018	1225	-	۲Þ	$\overline{\mathbf{V}}$					
$(\mathfrak{I})$	SS-COR-010	s	5/7/2018	1235	1	٩A						
Ð	SS-COR-012	s 5	5/7/2018	1410	1	٨A	$\langle \rangle$					
$(\mathcal{S})$	SS-COR-013	s 5	5/7/2018	1420	1	AN						
		S	1	/		NA						
		s		/	7	NA						
*Time Zone (Circle): E	EST CST (MST) PST Matrix 0 = oil S = soil	NS = non-soil solid	W = water L =	: liquid E = extra	act F=filter							1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.
For metals or anio	ns, please detail analytes below.							BIGNATURE	PRIN	TED NAME	DATE	TME
Comments:		CIC PACKAG	JE (check below)		RELIN	DUISHED BY	N)	Cred	Weter	1-101	7-2-18	100
		Щ	EVEL II (Standard Q	ô	æ	ECEIVED BY	1	Ø	KEL 1 -	JEAN SNITI	13248	0420
			EVEL III (Std QC + f	orms)	RELIN	QUISHED BY	Þ					
<u></u>		<u> </u>	EVEL IV (Std QC + 1 w data)	forms +	E	ECEIVED BY	}		:			

RELINQUISHED BY RECEIVED BY

1-HCI 2-HNO3 3-H2SO4 4-NaOH 5-NaHSO4 7-Other 8-4 degrees C 9-5035

CONDITIO	ALS Environmental ON OF SAMPLE UI	- Fort Collins PON RECEIPT FORM	1	<b>.</b>		
Client: STANTEC	-	Workorder No:	- 15	NTU	YD	
Project Manager:	RS	Initials:	Date:	7.1	518	_
Are airbills / shipping documents present	and/or removable?			DROP OFF	YES	NO
Are custody seals on shipping containers	intact?			NONE	YES	) NO
Are custody seals on sample containers in	ntact?			NONE	) YES	NO
ls there a COC (chain-of-custody) present	t?			$\sim$	(YES)	NO
Is the COC in agreement with samples rea matrix, requested analyses, etc.)	ceived? (IDs, dates,	times, # of samples, #	of conta	iners,	YES	NO
Are short-hold samples present?					YES	NO
Are all samples within holding times for t	he requested analys	ses?			YES	NO
Were all sample containers received intac	t? (not broken or le	eaking)			(YES)	) NO
Is there sufficient sample for the requeste	d analyses?				(YES)	NO
Are all samples in the proper containers f	or the requested and	alvses?			(YES))	NO
Are all aqueous samples preserved correc	tly, if required? (ex	cluding volatiles)		(N/A	YES	NO
Are all aqueous non-preserved samples n	H 4-9?			(N/A)	YES	NO
Are all samples requiring no headspace (V) of bubbles $> 6 \text{ mm} (1/4 \text{ inch})$ diameter? (1)	VOC, GRO, RSK/M	IEE, Rx CN/S, radon	) free	N/A	YES	NO
Were the samples shipped on ice?					VES	Tio
were the samples simpled on ree:	IR gun	·····		RAD		
$\label{eq:constraint} \begin{array}{c} Temperature (^{\circ}C): \\ \hline No. \ of \ custody \ seals \ on \ cooler: \\ \hline \\ $	<u>1 mb</u> <u>1</u> <u>14</u> <u>13</u> dwithin DOT acceptance		(If po. con	Earm 008 )		
.dditional Information: Please provide details he	ere for any NO responses	to gray shaded boxes above	2, or any o	ther issues	noted:	
Sapplicable, was the client contacted? YES / NO / Na         Project Manager Signature / Date:         Form 201r26.xls         (06/29/2018)	A Contact: *IR Gun #1, VWR SN *IR Gun #3, VWR SN	<del>7/5/18</del> 170560549 170647571		_ Date/Ti	me:	of [



## Gamma Spectroscopy Results PAI 713 Rev 14 Method Blank Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1807040 Client Name: Stantec Consulting Services ClientProject ID: St. Anthony 233001076

Lab ID:	GS180719-1MB

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Jul-18 Date Prepared: 18-Jul-18 Date Analyzed: 08-Aug-18 Prep Batch: GS180719-1 QCBatchID: GS180719-1-1 Run ID: GS180719-1A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 181595d03

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	-0.04 +/- 0.19	0.36	0.5	NA	U

### Comments:

#### Qualifiers/Flags:

- U  $\,$  Result is less than the sample specific MDC or less than the associated TP
- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- M Requested MDC not met.
- B Analyte concentration greater than MDC.
- B3 Analyte concentration greater than MDC but less than Requested MDC.
- DL Decision Level

## Data Package ID: GSS1807040-1

TPU - Total Propagated Uncertainty

Abbreviations:

- MDC Sample specific Minimum Detectable Concentration
- **BDL** Below Detection Limit

## **Gamma Spectroscopy Results**

PAI 713 Rev 14

Laboratory Control Sample(s)

Lab Name: ALS -- Fort Collins

Work Order Number: 1807040 Client Name: Stantec Consulting Services ClientProject ID: St. Anthony 233001076

Lab ID: GS180719-1LCS

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 18-Jul-18 Date Prepared: 18-Jul-18 Date Analyzed: 08-Aug-18 Prep Batch: GS180719-1 QCBatchID: GS180719-1-1 Run ID: GS180719-1A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 181110d05

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Contro I Limits	Lab Qualifier
13982-63-3	Ra-226	463 +/- 54	2	468.3	98.9	85 - 115	P,M3

### **Comments:**

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP TPU - Total Propagated Uncertainty LT - Result is less than Requested MDC, greater than sample specific MDC. MDC - Minimum Detectable Concentration Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed. Y2 - Chemical Yield outside default limits. SQ - Spectral quality prevents accurate quantitation. L - LCS Recovery below lower control limit. SI - Nuclide identification and/or quantitation is tentative. H - LCS Recovery above upper control limit. TI - Nuclide identification is tentative. P - LCS Recovery within control limits. R - Nuclide has exceeded 8 halflives. M - The requested MDC was not met. M3 - The requested MDC was not met, but thereported activity is greater than the reported MDC.

### Data Package ID: GSS1807040-1

Abbreviations:

## **Gamma Spectroscopy Results**

PAI 713 Rev 14 Duplicate Sample Results (DER)

Lab Name: ALS -- Fort Collins

Work Order Number: 1807040 Client Name: Stantec Consulting Services ClientProject ID: St. Anthony 233001076

Field ID: State ID: 18 Lab ID: 18 Libr	S-COR-012 307040-7DUP rary: RA226.LIB	Sample Matrix: SOIL Prep SOP: PAI 739 Date Collected: 07-May- Date Prepared: 18-Jul-18 Date Analyzed: 08-Aug-1	Rev 12 18 3	Prep I QCBa R Count Report	Batch: GS180719-1 tchID: GS180719-1-1 un ID: GS180719-1A Time: 30 minutes Basis: Dry Weight	Final Aliquo Prep Basi Moisture(% Result Unit File Nam	ot: 228 g is: Dry Weig io: NA is: pCi/g ie: 181310d0	ht D1	
CASNO	Analyte	Sample Result +/- 2 s TPU	MDC	Flags	Dupl Result +/- 2 s TPU	icate MDC	Flags	DER	DER Lim
13982-63-3	Ra-226	6.63 +/- 0.87	0.47		5.91 +/- 0.82	0.51	M3	0.603	2.13

#### **Comments:**

Duplicate Qualifiers/Flags:		Abbreviations:
U - Result is less than the sample specific MDC.		TPU - Total Propagated Uncertainty
$\ensuremath{Y1}$ - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.		DER - Duplicate Error Ratio
Y2 - Chemical Yield outside default limits.		BDL - Below Detection Limit
W - DER is greater than Warning Limit of 1.42		NR - Not Reported
D - DER is greater than Control Limit of 2.13		
LT - Result is less than Request MDC, greater than sample specific MDC		
M - Requested MDC not met.		
M3 - The requested MDC was not met, but the reported	SQ - Spectral quality prevents accurate quantitation.	
1 - LCS Recovery below lower control limit	SI - Nuclide identification and/or quantitation is tentative.	
H - LCS Recovery above upper control limit	TI - Nuclide identification is tentative.	
P-LCS Matrix Spike Recovery within control limits	R - Nuclide has exceeded 8 halflives	
N - Matrix Spike Recovery outside control limits	G - Sample density differs by more than 15% of LCS density	

### Data Package ID: GSS1807040-1

Sample Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1807040 Client Name: Stantec Consulting Services ClientProject ID: St. Anthony 233001076

Library:       RA226.LIB       Date Prepared:       18-Jul-18       Count Time:       30 minutes       Result Units:       pCi/g         Date Analyzed:       08-Aug-18       Report Basis:       Dry Weight       File Name:       181309d01	Field ID:         SS-COR-004           Lab ID:         1807040-1	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18	Prep Batch: GS180719-1 QCBatchID: GS180719-1-1 Run ID: GS180719-1A	Final Aliquot: 210 g Prep Basis: Dry Weight Moisture(%): NA
Date Analyzed:       08-Aug-18       Report Basis:       Dry Weight       File Name:       181309d01	Library: RA226.LIB	Date Prepared: 18-Jul-18	Count Time: 30 minutes	Result Units: pCi/g
		Date Analyzed: 08-Aug-18	Report Basis: Dry Weight	File Name: 181309d01
		Date Analyzed: 08-Aug-18	Report Basis: Dry Weight	File Name: 181309d01

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	25.3 +/- 3.1	0.9	0.5	NA	M3

### Comments:

#### Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1807040-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

G - Sample density differs by more than 15% of LCS density.

Sample Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1807040 Client Name: Stantec Consulting Services ClientProject ID: St. Anthony 233001076

Field ID:         SS-COR-005           Lab ID:         1807040-2	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-Mav-18	Prep Batch: GS180719-1 QCBatchID: GS180719-1-1 Run ID: GS180719-1A	Final Aliquot: 200 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 18-Jul-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 08-Aug-18	Report Basis: Dry Weight	File Name: 181276d02

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	6.36 +/- 0.86	0.55	0.5	NA	M3

### Comments:

#### Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1807040-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

G - Sample density differs by more than 15% of LCS density.

Sample Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1807040 Client Name: Stantec Consulting Services ClientProject ID: St. Anthony 233001076

Field ID:         SS-COR-007           Lab ID:         1807040-3	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18	Prep Batch: GS180719-1 QCBatchID: GS180719-1-1 Run ID: GS180719-1A	Final Aliquot: 232 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 18-Jul-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 08-Aug-18	Report Basis: Dry Weight	File Name: 181594d03

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	2.73 +/- 0.45	0.48	0.5	NA	

### Comments:

#### Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1807040-1

- SQ Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

Sample Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1807040 Client Name: Stantec Consulting Services ClientProject ID: St. Anthony 233001076

Field ID:         SS-COR-008           Lab ID:         1807040-4	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18	Prep Batch: GS180719-1 QCBatchID: GS180719-1-1 Run ID: GS180719-1A	Final Aliquot: 230 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 18-Jul-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 08-Aug-18	Report Basis: Dry Weight	File Name: 181113d09

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	5.17 +/- 0.73	0.47	0.5	NA	

### Comments:

#### Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

M - The requested MDC was not met.

Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

DL - Decision Level

## Data Package ID: GSS1807040-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

G - Sample density differs by more than 15% of LCS density.

Sample Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1807040 Client Name: Stantec Consulting Services ClientProject ID: St. Anthony 233001076

Date C	ollected: 07-May-18	Run ID: GS180719-1A Moi	ep Basis: Dry weight isture(%): NA
Library: RA226.LIB Date P	repared: 18-Jul-18 Co	ount Time: 30 minutes Res	ult Units: pCi/g
Date A	nalyzed: 08-Aug-18 Rep	oort Basis: Dry Weight F	ile Name: 181178d10

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	29.7 +/- 3.5	0.6	0.5	NA	M3

### Comments:

#### Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1807040-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

G - Sample density differs by more than 15% of LCS density.

Sample Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1807040 Client Name: Stantec Consulting Services ClientProject ID: St. Anthony 233001076

Field ID:         SS-COR-010           Lab ID:         1807040-6	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18	Prep Batch: GS180719-1 QCBatchID: GS180719-1-1 Run ID: GS180719-1A	Final Aliquot: 236 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 18-Jul-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 08-Aug-18	Report Basis: Dry Weight	File Name: 181806d04

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	6.78 +/- 0.92	0.64	0.5	NA	M3

### Comments:

#### Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

M - The requested MDC was not met.

Abbreviations:

TPU - Total Propagated Uncertainty

MDC - Sample specific Minimum Detectable Concentration

BDL - Below Detection Limit

DL - Decision Level

## Data Package ID: GSS1807040-1

SQ - Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.

- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

Sample Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1807040 Client Name: Stantec Consulting Services ClientProject ID: St. Anthony 233001076

Field ID:         SS-COR-012           Lab ID:         1807040-7	Sample Matrix: SOIL	Prep Batch: GS180719-1	Final Aliquot: 224 g
	Prep SOP: PAI 739 Rev 12	QCBatchID: GS180719-1-1	Prep Basis: Dry Weight
	Date Collected: 07-May-18	Run ID: GS180719-1A	Moisture(%): NA
Library: RA226.LIB	Date Prepared: 18-Jul-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 08-Aug-18	Report Basis: Dry Weight	File Name: 181109d05

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	6.63 +/- 0.87	0.47	0.5	NA	

### Comments:

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1807040-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

G - Sample density differs by more than 15% of LCS density.

## **Gamma Spectroscopy Results**

PAI 713 Rev 14

Sample Duplicate Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1807040 Client Name: Stantec Consulting Services

ClientProject ID: St. Anthony 233001076

Field ID: SS-COR Lab ID: 1807040 Library:	R-012 0-7DUP RA226.LIB	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18 Date Prepared: 18-Jul-18 Date Analyzed: 08-Aug-18	Pre QCI Cou Repo	p Batch: GS180 BatchID: GS180 Run ID: GS180 nt Time: 30 minu rt Basis: Dry We	719-1 Fi 719-1-1 719-1A N utes R ight	nal Aliquot: 228 Prep Basis: Dry loisture(%): NA esult Units: pCi File Name: 181	g Weight /g 310d01
0.010	Tanna ( Nasal' da						1 -1

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	5.91 +/- 0.82	0.51	0.5	NA	M3

#### Comments:

#### Qualifiers/Flags:

- U Result is less than the sample specific MDC or less than the associated TPU.
- Y1 Chemical Yield is in control at 100-110%. Quantitative yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.

M - The requested MDC was not met.

- M3 The requested MDC was not met, but thereported activity is greater than the reported MDC.
- W DER is greater than Warning Limit of 1.42
- D DER is greater than Control Limit of 2.13

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- **BDL** Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1807040-1

### Date Printed:

Thursday, August 09, 2018

SQ - Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.

G - Sample density differs by more than 15% of LCS density.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

Sample Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1807040 Client Name: Stantec Consulting Services ClientProject ID: St. Anthony 233001076

Library:     RA226.LIB     Date Prepared:     18-Jul-18     Count Time:     30 minutes     Result Units:     pCi/g       Date     Analyzed:     08-Aug-18     Report Basis:     Dry Weight     File Name:     181277d02	Field ID:         SS-COR-013           Lab ID:         1807040-8	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18	Prep Batch: GS180719-1 QCBatchID: GS180719-1-1 Run ID: GS180719-1A	Final Aliquot: 240 g Prep Basis: Dry Weight Moisture(%): NA
Date Analyzed:       08-Aug-18       Report Basis:       Dry Weight       File Name:       181277d02	Library: RA226.LIB	Date Prepared: 18-Jul-18	Count Time: 30 minutes	Result Units: pCi/g
		Date Analyzed: 08-Aug-18	Report Basis: Dry Weight	File Name: 181277d02
		Date Analyzed. 00-Aug-10	Report Dasis. Dry Weight	

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	5.45 +/- 0.74	0.46	0.5	NA	

### Comments:

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1807040-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

G - Sample density differs by more than 15% of LCS density.



# Gamma Spectroscopy Case Narrative

# Stantec

## St. Anthony Geotechnical Investigation – 233001076

## Work Order Number: 1805265

- 1. The following report consists of analytical results for 16 soil samples received by ALS on 05/11/2018.
- 2. These samples were prepared according to the current revision of SOP 739. The samples were sealed in steel cans on 05/25/2018 and stored for at least 21 days to allow <sup>222</sup>Rn to approach secular equilibrium with its parent, <sup>226</sup>Ra. The degree of ingrowth achieved prior to analysis on 06/15/2018 is at least 97.8%. Conservatively assuming a radon emanation efficiency of approximately 50%, the effective radon progeny ingrowth for these samples would be greater than 98.9%.
- 3. The samples were analyzed for the presence of gamma emitting radionuclides according to the current revision of SOP 713. The analyses were completed on 06/15/2018.
- 4. The results for these samples are reported on a "Dry Weight" basis in units of pCi/gram.
- 5. ALS has observed a reproducible low bias in <sup>226</sup>Ra results (about -30% for the geometry in question) when using a mixed gamma source for the calibration of HPGe detectors for solid samples. This bias is eliminated by calibration using a NIST traceable <sup>226</sup>Ra source in the same geometry and configuration as the samples.
- 6. The library used for calibration and analysis employs multiple peaks for the <sup>226</sup>Ra progeny, <sup>214</sup>Pb (352 and 295 keV) and <sup>214</sup>Bi (609 and 1120 keV). Using these peaks avoids the use of the problematic <sup>226</sup>Ra photopeak at 186 keV, which suffers from poorly resolvable interference from <sup>235</sup>U at the same energy. Final activity results for <sup>226</sup>Ra are calculated, using the uncertainty-weighted mean of the activities for the four photopeaks, by the Seeker gamma spectroscopy software assuming secular equilibrium.



- 7. Activity concentrations above the calculated MDC are reported in some instances where minimum nuclide identification criteria are not met. Such tentative identifications result when the software attempts to calculate net activity concentrations for analytes where either one or both of the following criteria are not satisfied: the 'diagnostic' peak for a nuclide must be identified above the critical level, or the minimum library peak abundance must be attained. Nuclides not meeting these requirements have been flagged with a "TI" qualifier.
- 8. There are cases where the sample density is less or greater than the associated calibration standard density. Cases that exceed the limit of +/- 15% of the density of the calibration standard are flagged with a 'G', denoting a significant density difference between the sample and calibration standard. Consequently, the results may be biased low for samples 1805265-3 and -4 and biased high for sample 1805265-6. If requested, ALS can perform a transmission spike in order to estimate a magnitude of this bias. The results are reported without further qualification.
- The requested detection limit for <sup>226</sup>Ra was not met for samples 1805265-3, -4, -5, -5DUP, -6, -11, -13, and -15. The reported activity for these samples exceeds the achieved MDC. Results are submitted without further qualification. The results are identified with an "M3" qualifier on the final report.
- 10. No further problems were encountered with either the client samples or the associated quality control samples. All remaining quality control criteria were met.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

Jean Anderson Radiochemistry Primary Pata Reviewer

Radio nemistry Final Data Reviewer

<u>6/18/18</u> Date

6/20/18 Date

# **ALS -- Fort Collins**

## Sample Number(s) Cross-Reference Table

OrderNum: 1805265 Client Name: Stantec Client Project Name: St. Anthony Geotechnical Investigation Client Project Number: 233001076 Client PO Number: 233001076

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
SS-COR-001	1805265-1		SOIL	07-May-18	8:38
SS-COR-002	1805265-2		SOIL	07-May-18	8:52
SS-COR-003	1805265-3		SOIL	07-May-18	9:15
SS-COR-203	1805265-4		SOIL	07-May-18	9:30
SS-COR-004	1805265-5		SOIL	07-May-18	9:55
SS-COR-005	1805265-6		SOIL	07-May-18	10:35
SS-COR-006	1805265-7		SOIL	07-May-18	11:05
SS-COR-206	1805265-8		SOIL	07-May-18	11:20
SS-COR-007	1805265-9		SOIL	07-May-18	11:55
SS-COR-008	1805265-10		SOIL	07-May-18	12:05
SS-COR-009	1805265-11		SOIL	07-May-18	12:25
SS-COR-010	1805265-12		SOIL	07-May-18	12:35
SS-COR-011	1805265-13		SOIL	07-May-18	13:25
SS-COR-012	1805265-14		SOIL	07-May-18	14:10
SS-COR-013	1805265-15		SOIL	07-May-18	14:20
SS-COR-014	1805265-16		SOIL	07-May-18	15:35

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COMPANY NAME	Stantec	BILL TO COM	PANY Sta	ntec			(								
SEND REPORT TO	Toby Leeson	INVOICE AT	TN TO Me	lanie Davis			рәуі								
ADDRESS	2103 Resort Dr. Suite 350	ADC	NESS 332	5 S. Timberlin	le Rd Suite	150	рош						<u>.</u>		
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E-MAR.	toby.keeson@stantec.com	Ű	MAIL III	elanie.davis@	ĝstantec.cu		ะม 								
Lab ID	Field ID	Matrix	Sample Date	Sample Time	Botties #	78°.	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~					-			
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(2)	SS.cer-co4	S	5-7-18	0955		AN	$\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{$								
(m)	55 - COR-005	s	5-7-18	1035		AN									
È	55-202-006	S	5-7-18	1105		<b>V</b>	7								
X	55-206	S	5-7-18	0211		NA	3								
B	55 -ciok - 007	S	5-7-18	1155	~	AA	>								
Q	55.608.008	S	5-7-18	1205	~	AN	7								
*Time Zone (Circle):	EST CST (MSD PST Matrix: O = oil S = soil	NS = non-soil soli	d W = water (	. = liquid E = ext	tract F=filte	•									
For metals or anix	ons, please detail analytes below.			[				SIGNATI	URE	•	RINTED NAME		DATE	-	IME
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4 0							LEVEL IV ( raw data)	Std QC + form
f 2								
Preservative Key:	1-HCI	2-HNO3	3-H2SO4	4-NaOH	5-NaHSO4	7-Other	8-4 degrees C	9-5035

RELINQUISHED BY RECEIVED BY

	ALS Environmental 225 Commerce Drive, Fort Collins, Colorado 80524	_			Chain	-of-Cu	stody	_				WORKORDER #			) / / (	
	TF: (800) 443-1511 PH: (970) 490-1511 FX: (970) 490-15	522								Fo	rm 202r8			$\tilde{O}$	دلار	^
(ALS)		SAN		lictor P.	tel			õ	VTE 5-5	8-18		PAGE	3	of	ц	
PROJECT NAME	St. Anthony	8	ITE ID St	. Anthony				TURNARO	ND Stand	ard		DISPOSAL	By Lab	or	eturn to C	lient
PROJECT No.	. 233001076	EDD FO	RMAT													
		PURCHASE O	RDER 2	3300107	6-40	s	I									
COMPANY NAME	: Stantec	BILL TO COM	PANY St	antec			(									
SEND REPORT TO	Toby Leeson	INVOICE AT	TN TO M	elanie Davis			pəyi									
ADDRESS	2103 Resort Dr. Suite 350	ADC	RESS 33	25 S. Timberlin	e Rd Suit	e 150	pow									
CITY / STATE / ZIP	Steamboat, CO 80487	CITY / STAT	E/ZIP Fo	rt Collins, CO 8	30525		1.10	·								
PHONE	970-871-4361		HONE	70-212-2749			)6) 9 									
FAX			FAX				52 6									
E-MAR	toby.keeson@stantec.com		MAIL	nelanie. davis@	stantec.c	om	ะย 									
Lab ID	Field ID	Matrix	Sample Date	Sample Time	# Bottles انگ عرب	Pres.	0						· · ·			
(11)	SS-COR-OOD	S	5-7-18	1225	-	AN	>									
(U)	SS-COR-DID	s	5-7-18	1235	-	AN	>									
(3)	55-COR-011	s	5-7-18	1325	1	AN	$\checkmark$									
(hL)	25-202-012	S	5-7-18	1410		NA	7									
(G)	55-208-013	S	5-7-18	OCHI	1	٩										
(D)	55-602-014	S	5-7-18	1535	1	AA	<									
)		S				NA										
		S				NA										
		s				AN										
		s				NA										
*Time Zone (Circle):	EST CST (MST) PST Matrix 0 = oil S = soil	INS = non-soil soli	d W = water	L=liquid E=ext	ract F=filte	*										
For metals or an	ions, piease detail analytes below.							SIGN	ATURE		PRIV	TED NAME	dono 9 or or 	DATE	TIMIT	
Comments:		OC PACK	IGE (check belo	5	RELI	NQUISHED			K	_	Victor	Patel	ý	8-18	/338	a
			EVEL II (Standar	d ac)		RECEIVED		V	M	7	XEL 1 - 1	EAN SMIT	√ ∓	11-18	1242	
4			EVEL II) (SId QC	+ forms)	REL	NQUISHED	2	X								
5 of			.EVEL IV (Std Q( aw data)	+ forms +		RECEIVED	2						-			Т
f 2					REL	NQUISHED	à						-			
Preservative Key:	1-HCi 2-HNO3 3-H2SO4 4-NaOH 5-NaHSO4	4 7-Other 8-4 de	grees C 9-50	8		RECEIVED	β									



### ALS Environmental - Fort Collins CONDITION OF SAMPLE UPON RECEIPT FORM

(ALS)					. /		-	
Client:	STANTEC		Worko	rder No:	_//	NS21	'e 5	-
Project Manager:	KS			Initials:	KÆ	Date:	<u>S11</u>	18
1. Does this project requir	e any special handling in addition	n to standard	ALS proc	cedures? (	$\frown$		YES	(NO)
2. Are custody seals on	shipping containers intact?					MONE	YES	NO
3. Are Custody seals on	sample containers intact?				(	NONE	YES	NO
4. Is there a COC (Chair	n-of-Custody) present or other	r representa	itive docu	uments?			(TES)	NO
5. Are the COC and bot	tle labels complete and legible	e?				1	YES	NO
<ol> <li>Is the COC in agreem of containers, matrix,</li> </ol>	nent with samples received? (2) requested analyses, etc.)	IDs, dates, ti	mes, no. (	of samples.	, no.		YES	NO
7. Were airbills / shipping	ng documents present and/or n	removable?				DROP OFF	YES	NO
8. Are all aqueous samples	s requiring preservation preserved	d correctly?	(excluding	g volatiles)		(N/A)	YES	NO
<ol> <li>Are all aqueous non-r</li> </ol>	preserved samples pH 4-9?					N/A	YES	NO
10. Is there sufficient san	nple for the requested analyse	s?					YES	NO
11. Were all samples place	ced in the proper containers for	or the reque	sted anal	yses?			TYES	NO
12. Are all samples within	n holding times for the reques	ted analyse	s?			ļ	(YES	NO
13. Were all sample conta	ainers received intact? (not b	roken or lea	aking, etc	.)			(YES)	NO
<sup>14</sup> Are all samples require headspace free?	ring no headspace (VOC, GR Size of bubble: < green	O, RSK/MI pea	EE, Rx C > gree	N/S, radon n pea	1)	N/A	YES	NO
15. Do any water samples	s contain sediment?			A	mount	(N/A)	YES	NO
Amount of sediment:	dusting moder	ate	heavy					
<sup>16.</sup> Were the samples shi	pped on ice?	IP mm					YES	<u>NOX</u>
<sup>17.</sup> Were cooler temperat	tures measured at 0.1-6.0°C?	used*:	#1	#3	#4	ONLY	YES	(NO/
	Cooler #:	<u></u>				<u> </u>		
	Temperature (°C): Amb	Anh_			<u> </u>			
No. of cus	tody seals on cooler:	<u> </u>						
DOT Survey/ Acceptance Ext	ternal $\mu$ R/hr reading: <u>12</u>	<u>P</u>						
Backg	round $\mu R/hr$ reading: <u>13</u>		$\sim$	1				
Were external µR/hr readings	≤ two times background and within DO	T acceptance cr	iteria?/YE	S/ NO / NA	(lf no, see	Form 008.)		
				2				

Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE, EXCEPT #1 AND #16.

te/Time:

\*IR Gun #1, VWR SN 170560549 \*IR Gun #3, VWR SN 170647571 \*IR Gun #4, Oakton, SN 2372220101-0002

Page 1 of \_



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## Gamma Spectroscopy Results PAI 713 Rev 14 Method Blank Results

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

l ah	יחו	GS180530-1MB
Lau	ID.	00100000-1100

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 25-May-18 Date Prepared: 25-May-18 Date Analyzed: 15-Jun-18 Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 181040d03

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	-0.01 +/- 0.18	0.35	0.5	NA	U

#### **Comments:**

#### Qualifiers/Flags:

- U  $\,$  Result is less than the sample specific MDC or less than the associated TP
- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- M Requested MDC not met.
- B Analyte concentration greater than MDC.
- B3 Analyte concentration greater than MDC but less than Requested MDC.
- DL Decision Level

### Data Package ID: GSS1805265-1

Abbreviations:

TPU - Total Propagated Uncertainty

- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit

Page 1 of 1

## **Gamma Spectroscopy Results**

PAI 713 Rev 14

Laboratory Control Sample(s)

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

#### Lab ID: GS180530-1LCS

Library: RA226.LIB

Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 25-May-18 Date Prepared: 25-May-18 Date Analyzed: 15-Jun-18 Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A Count Time: 30 minutes Final Aliquot: 215 g Result Units: pCi/g File Name: 180678d05

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Contro I Limits	Lab Qualifier
13982-63-3	Ra-226	468 +/- 55	2	468.3	100	85 - 115	P,M3

#### Comments:

#### Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP TPU - Total Propagated Uncertainty LT - Result is less than Requested MDC, greater than sample specific MDC. MDC - Minimum Detectable Concentration Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed. Y2 - Chemical Yield outside default limits. SQ - Spectral quality prevents accurate quantitation. L - LCS Recovery below lower control limit. SI - Nuclide identification and/or quantitation is tentative. H - LCS Recovery above upper control limit. TI - Nuclide identification is tentative. P - LCS Recovery within control limits. R - Nuclide has exceeded 8 halflives. M - The requested MDC was not met. M3 - The requested MDC was not met, but thereported activity is greater than the reported MDC.

### Data Package ID: GSS1805265-1

Abbreviations:

## **Gamma Spectroscopy Results**

PAI 713 Rev 14 Duplicate Sample Results (DER)

Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:SS-COR-004Lab ID:1805265-5DUPLibrary:RA226.LIB		Sample Matrix: SOIL Prep SOP: PAI 739 Date Collected: 07-May- Date Prepared: 25-May- Date Analyzed: 15-Jun-	Rev 12 18 18 18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A Count Time: 30 minutes Report Basis: Dry Weight		Final Aliquot: 209 g Prep Basis: Dry Weight Moisture(%): NA Result Units: pCi/g File Name: 180731d10		yht 10	
CASNO	Analyte	Sample Result +/- 2 s TPU	MDC	Flags	Dupli Result +/- 2 s TPU	cate MDC	Flags	DER	DER Lim
13982-63-3	Ra-226	36.0 +/- 4.4	0.9	M3	34.7 +/- 4.1	0.6	M3	0.211	2.13

#### Comments:

Duplicate Qualifiers/Flags:		Abbreviations:
U - Result is less than the sample specific MDC.		TPU - Total Propagated Uncertainty
Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.		DER - Duplicate Error Ratio
Y2 - Chemical Yield outside default limits.		BDL - Below Detection Limit
W - DER is greater than Warning Limit of 1.42		NR - Not Reported
D - DER is greater than Control Limit of 2.13		
LT - Result is less than Request MDC, greater than sample specific MDC		
M - Requested MDC not met.		
M3 - The requested MDC was not met, but the reported	SQ - Spectral quality prevents accurate quantitation.	
L - LCS Recovery below lower control limit.	SI - Nuclide identification and/or quantitation is tentative.	
H - LCS Recovery above upper control limit.	TI - Nuclide identification is tentative.	
P - LCS, Matrix Spike Recovery within control limits.	R - Nuclide has exceeded 8 halflives.	
N - Matrix Spike Recovery outside control limits	G - Sample density differs by more than 15% of LCS density.	

### Data Package ID: GSS1805265-1
### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-001           Lab ID:         1805265-1	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-Mav-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Bun ID: GS180530-1A	Final Aliquot: 224 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 181285d04

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.85 +/- 0.27	0.45	0.5	NA	TI

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1805265-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-002           Lab ID:         1805265-2	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A	Final Aliquot: 233 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180676d05

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.83 +/- 0.20	0.28	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-003           Lab ID:         1805265-3	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A	Final Aliquot: 248 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180812d07

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	43.9 +/- 5.3	0.9	0.5	NA	M3,G

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1805265-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-203           Lab ID:         1805265-4	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-Mav-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A	Final Aliquot: 248 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180726d08

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	41.1 +/- 4.9	0.8	0.5	NA	M3,G

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1805265-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-004           Lab ID:         1805265-5	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A	Final Aliquot: 212 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180717d09

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	36.0 +/- 4.4	0.9	0.5	NA	M3

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1805265-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

# **Gamma Spectroscopy Results**

PAI 713 Rev 14

Sample Duplicate Results

Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:SS-CLab ID:18052	OR-004 265-5DUP	Sample Matrix: SOIL         Prep Batch: GS180530-1         Final Aliquot: 20           Prep SOP: PAI 739 Rev 12         QCBatchID: GS180530-1-1         Prep Basis: DI           Date Collected: 07-May-18         Run ID: GS180530-1A         Moisture(%): NJ		Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A		Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A		nal Aliquot: 209 Prep Basis: Dry oisture(%): NA	g Weight
Library	<b>r:</b> RA226.LIB	RA226.LIB     Date Prepared: 25-May-18     Count Time: 30       Date Analyzed: 15-Jun-18     Report Basis: D		Count Time: 30 minutes Report Basis: Dry Weight		esult Units: pCi File Name: 180	/g 731d10		
CASNO	Torgot Nuclido			MDC	Domuceted		Lab		

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	34.7 +/- 4.1	0.6	0.5	NA	M3

## **Comments:**

### Qualifiers/Flags:

- U Result is less than the sample specific MDC or less than the associated TPU.
- Y1 Chemical Yield is in control at 100-110%. Quantitative yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M The requested MDC was not met.
- M3 The requested MDC was not met, but thereported activity is greater than the reported MDC.
- W DER is greater than Warning Limit of 1.42
- D DER is greater than Control Limit of 2.13

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1805265-1

## Date Printed:

Monday, June 18, 2018

SQ - Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.

G - Sample density differs by more than 15% of LCS density.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-005           Lab ID:         1805265-6	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-Mav-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A	Final Aliquot: 181 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180845d01

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	8.5 +/- 1.2	0.6	0.5	NA	M3,G

## **Comments:**

### Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1805265-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-006           Lab ID:         1805265-7	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-Mav-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Bun ID: GS180530-1A	Final Aliquot: 225 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180812d02

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.75 +/- 0.22	0.40	0.5	NA	

## **Comments:**

### Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1805265-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-206           Lab ID:         1805265-8	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-Mav-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Bun ID: GS180530-1A	Final Aliquot: 223 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 181039d03

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	0.74 +/- 0.27	0.44	0.5	NA	TI

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

## Data Package ID: GSS1805265-1

SQ - Spectral quality prevents accurate quantitation.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

SI - Nuclide identification and/or quantitation is tentative.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-007           Lab ID:         1805265-9	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A	Final Aliquot: 227 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 181286d04

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	3.09 +/- 0.49	0.46	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-008           Lab ID:         1805265-10	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-Mav-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Bun ID: GS180530-14	Final Aliquot: 228 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180677d05

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	6.76 +/- 0.89	0.46	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-009           Lab ID:         1805265-11	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-Mav-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A	Final Aliquot: 232 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180813d07

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	37.4 +/- 4.5	0.8	0.5	NA	M3

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-010           Lab ID:         1805265-12	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-Mav-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A	Final Aliquot: 236 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180727d08

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	9.1 +/- 1.2	0.4	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-011           Lab ID:         1805265-13	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A	Final Aliquot: 235 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180718d09

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	69.2 +/- 8.2	1.0	0.5	NA	M3

## Comments:

## Qualifiers/Flags:

 ${\sf U}~$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-012           Lab ID:         1805265-14	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A	Final Aliquot: 219 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180732d10

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	9.5 +/- 1.2	0.4	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

#### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-013           Lab ID:         1805265-15	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-Mav-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A	Final Aliquot: 232 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180846d01

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	8.5 +/- 1.1	0.5	0.5	NA	M3

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation. SI - Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

### Lab Name: ALS -- Fort Collins

Work Order Number: 1805265

Client Name: Stantec

ClientProject ID: St. Anthony Geotechnical Investigation 233001076

Field ID:         SS-COR-014           Lab ID:         1805265-16	Sample Matrix: SOIL Prep SOP: PAI 739 Rev 12 Date Collected: 07-May-18	Prep Batch: GS180530-1 QCBatchID: GS180530-1-1 Run ID: GS180530-1A	Final Aliquot: 215 g Prep Basis: Dry Weight Moisture(%): NA
Library: RA226.LIB	Date Prepared: 25-May-18	Count Time: 30 minutes	Result Units: pCi/g
	Date Analyzed: 15-Jun-18	Report Basis: Dry Weight	File Name: 180813d02

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Requested MDC	DL	Lab Qualifier
13982-63-3	Ra-226	1.25 +/- 0.27	0.41	0.5	NA	

## **Comments:**

## Qualifiers/Flags:

U  $\,$  - Result is less than the sample specific MDC or less than the associated TP

- Y1 Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
- Y2 Chemical Yield outside default limits.
- LT Result is less than Requested MDC, greater than sample specific MDC.
- M3 The requested MDC was not met, but the reported activity is greater than the reported MDC.
- M The requested MDC was not met.

#### Abbreviations:

- TPU Total Propagated Uncertainty
- MDC Sample specific Minimum Detectable Concentration
- BDL Below Detection Limit
- DL Decision Level

- SQ Spectral quality prevents accurate quantitation.
- SI Nuclide identification and/or quantitation is tentative.
- TI Nuclide identification is tentative.
- R Nuclide has exceeded 8 halflives.
- G Sample density differs by more than 15% of LCS density.

## **TECHNICAL BULLETIN ADDENDUM**

The library used for analysis defines the gamma emission(s) to be used for analysis of each nuclide. If multiple gamma emissions are used for quantification, then a 'NET' quantification emission (or peak) must be defined in the library. This designation provides for the calculation of nuclide activity concentrations and detection limits in the case of non-presence of the nuclide. When the nuclide is not present, or the software is unable to resolve a peak at the library defined 'NET' energy, the software evaluates the 'NET' region of interest ('NET' peak energy +/- 2 keV) by performing a summation of the net counts above the background level. This 'NET' quantification can result in net negative, zero, or positive activity results, and is highly dependent on the spectral distribution in the region of interest of the 'NET' peak. In cases where only the 'NET' peak is found, and the software performs a net quantification, the nuclide result will be flagged with an 'NQ' qualifier on the final reports. This indicates that the nuclide is not detected or supported at any level above the reported MDC. Results are submitted without further qualification.

All nuclides specified in the library of analysis for gamma spectroscopy are evaluated for positive <u>OR</u> tentative identification on the following criteria:

- The individual abundances for the gamma emissions specified for each nuclide are summed to obtain a total nuclide abundance.
- From the total nuclide abundance, a positive identification criterion is set as 75% of this total nuclide abundance.
- For all nuclide peaks that are not net quantified, those peak abundances are summed. The total non-net quantified peak sum is compared to the calculated 75% abundance criterion. If this sum is greater than the 75% criterion, the nuclide is considered to be positively identified at the reported concentration. If the sum is less than the 75% criterion, the nuclide is tentatively identified at the reported concentration. These results will be flagged with a 'TI' qualifier on the final reports to indicate that the 75% abundance criterion was not met.

## Appendix D Radiologic Instrument Calibration and Operational Function Check Documentation

## **AVM Environmental Services Inc.**

## Scaler/Ratemeter Calibration Form

Model : L2221

S/N: 68782

Reference Instrument/Source: Ludlum Pulser 500, S/N:114513

**HV** Calibration

HV Readout (2 points): Ref/Inst 600 / 600 Ref/Inst 990 / 1000

## **Ratemeter Calibration**

Instrument Threshold @ 100 (10 mV), WIN: Out, HV 900VDC; Pulser Threshold @ 200 (20mV)

Range/Mode	Range Multiplier	Calibration Point (Pulser Setting) cpm x multiplier	Target CPM (±5%)	As Found Reading	Left or Set Reading
Ratemeter	x1	40x1	38-42	38-41	38-41
	x1	40x10	380-420	400	400
	x10	40x100	3800-4200	4000	4000
	x100	40x1K	38K-42K	40000	40000
	x1K	40x10K	380K-420K	400000	400000
Digital Ratemeter	-	40x1	38-42	38-41	38-41
	-	40x10	380-420	394-400	394-400
	-	40x100	3800-4200	3964-4000	3964-4000
	-	40x1K	38K-42K	39K-40K	39K-40K
		40x10K	380K-420K	397K-400K	397K - 400K

### **Threshold/Gain Calibration**

WIN OUT

Pulser Amplitude (mV)	Pulser CPM	L2221 Theshold (mv)	Target CPM	L2221 CPM Found	L2221 CPM Left or Set @
10.0	40000	100 (10 mV)	27K -33K	30706	30706
20.0	40000	200 (20 mV)	27K -33K	32190	32190
30.0	40000	300 (30 mV)	27K -33K	31635	31635
40.0	40000	400 (40 mV)	27K -33K	30918	30918
50.0	40000	500 (50 mV)	27K -33K	31244	31244

Note: Use R174 Gain Control on Power Supply Board to adjust L2221 CPM @75% for Threshold/Gain Calibration

## Window Cut-off Points Check

L2221 Threshold set @100 (10.0 mv) WIN @ 100 (10.0 mV) WIN @ 200 (20.0 mV)

WIN @ 400 (40.0 mV) WIN @ 500 (50.0 mV)

Date 8-1-17

Calibrated By

Customer AV	Model No. / M ENVIRONMENTA	CERTIFIC/ Serial No. 500	ate of calib 1 JJ4513	RATION	501 Oak Street 325-235-5494 Sweetwater, TX 79556,	U.S.A.	ACCREDITE CERT # 4084.0 14713/451652
Date	5-Jui-17	Cal Due D	Date	5-Jul-18	Cal. Interval 1	Year Procedure	M500, Rev. 5
T. <u>72</u> °F	RH	49 % Alt	707.0 mm Hg	Meter	Zeroed Mechan CUSTOMER PO	nical Check	
	As Found	As Left	Accepta Range (	ble µs) ± 10%			
NEG PULSE	1.7	1.7	1.5 -	1.9			
POS PULSE	1.6	1.6	< 2.:	25			
	a second a second as a second	a to be a set of the set	PULSE AMPLIT	UDE			
Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%	Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%
1 V	11	11	0.9 - 1.1	4 V	4.2 V	4.2 V	3.6 - 4.4
100 mV	100 m V	100 mV	90 - 110	400 mV	420 mV	420 mV	360 - 440
10 mV	10 mV	IOmV	9 - 11	40 mV	42 m V	42 m V	36 - 44
1 mV	1 - 1/	1.1	0.9 - 1.1	4 mV	4.2 - V	42. V	3.6 - 4.4

	PULSE FREQU	JENCY (PERIOD)		Reference	As Found	As Left	Acceptable
Pulser	As Found	As Left	Acceptable	Voltage	Voltage Reading	Voltage Reading	Range ± 5%
nge	Period	Period	Range ± 2%	500 V	500	500	475 - 525
x 10K	6.674	6.674	6.534 - 6.8	2000 V	1990	1990	1900 - 2100
x 1K	66.74	66.24	65.34 - 68				
x 100	667.4	667.4	653.4 - 680		As Found	As Left	Acceptable
x 10	6674	6674	6534 - 6800	CPM Reading	cpm Reading	cpm Reading	Range ± 10%
x1	66.75	66.75	65.34 - 68	MAX	992	992	981 - 999
x 0.1	90	90	88.2 - 91.8 Counts	MIN	0-1	0-1	0 - 1*

\* READING OF 0-99 IS ACCEPTABLE FOR INSTRUMENTS WITH A S/N 100000 AND BELOW AND MAIN BOARD = 5208-066

## COMMENTS:

Cal'd w/ 39" cable.

Ludium Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. ISO/IE 17025:2005(E)

Reference Instruments:		
Frequency Counter	Model	
Oscilloscope	Model GOS-6103 S/N EP832241 Cal Date 2-1-6 2017	
Voltmeter	Model Fluke B3 S/N 94000441 Cal Date 3. May 2017	
Trator William Tinak	iev Wieligram Tempeles Title Calibrator Date 5. Aulu 2017	
QC'd By R	Title Service Dept OC Date SJULD	

This certificate shall not be reproduced except in full, without the written approval of Ludium Measurements, Inc. FORM SC16-1 12/12/2018 Page \_\_\_\_\_\_\_ of \_\_\_\_\_

AC Inst.	3	Passed	Dielectric	(HH	Pot)	and	Contin	uity	Test	
Only [		Failed:		-		_				_

## **AVM Environmental Services Inc.**

## **Scaler/Ratemeter Calibration Form**

Model : L2221

S/N: 290801

Reference Instrument/Source: Ludlum Pulser 500, S/N:114513

**HV** Calibration

HV Readout (2 points): Ref/Inst 600 / 600 Ref/Inst 990 / 1000

## **Ratemeter Calibration**

Instrument Threshold @ 100 (10 mV), WIN: Out, HV 900VDC; Pulser Threshold @ 200 (20mV)

Range/Mode	Range Multiplier	Calibration Point (Pulser Setting) cpm x multiplier	Target CPM (±5%)	As Found Reading	Left or Set Reading
Ratemeter	xl	40x1	38-42	40	40
	x1	40x10	380-420	400	400
	x10	40x100	3800-4200	4000	4000
	x100	40x1K	38K-42K	40k	40k
	x1K	40x10K	380K-420K	HOCK	HOOK
Digital Ratemeter	-	40x1	38-42	40-41	40-41
	-	40x10	380-420	390-400	390-400
	-	40x100	3800-4200	3950-4000	3950-4000
	-	40x1K	38K-42K	39K -40K	39K -40K
	-	40x10K	380K-420K	395k-400k	395K -400K

#### **Threshold/Gain Calibration**

WIN OUT

Pulser Amplitude (mV)	Pulser CPM	L2221 Theshold (mv)	Target CPM	L2221 CPM Found	L2221 CPM Left or Set @
10.0	40000	100 (10 mV)	27K -33K	30756	30756
20.0	40000	200 (20 mV)	27K -33K	31443	31443
30.0	40000	300 (30 mV)	27K -33K	31128	3/128
40.0	40000	400 (40 mV)	27K -33K	30733	30733
50.0	40000	500 (50 mV)	27K -33K	31614	31614

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Note: Use R174 Gain Control on Power Supply Board to adjust L2221 CPM @75% for Threshold/Gain Calibration

## Window Cut-off Points Check

L2221 Threshold set @100 (10.0 mv) WIN @ 100 (10.0 mV) WIN @ 200 (20.0 mV)

WIN @ 400 (40.0 mV) WIN @ 500 (50.0 mV)

Date 8-1-17

Calibrated By

ww.ludiums.com	Model No. / M ENVIRONMENTA	CERTIFIC/ Serial No. 500	ate of calib	RATION	501 Oak Street 325-235-5494 Sweetwater, TX 79558,	U.S.A. RDER NO. 203	ACCREDITE CERT # 4084.0 14713/451652
Date	5-Jul-17 ment Instrument R	Cal Due E eceived I Within 1	Colerance 🗌 Out	5-Jul-18 of Tol. 🗍 Red	Cal. Interval1 quiring Repair            Oth	Year Procedure er-See Comments	<u>M500, Rev. 5</u>
T. <u>72</u> °F	F RH	49 % Alt	7 <u>07.0</u> mm Hg	Meter	Zeroed Mechar	nical Check	
	As Found	As Left	Accepta Range (	ble µs) ± 10%			
NEG PULSE	1.7	1.7	1.5 -	1.9			
POS PULSE	1.6	1.6	< 2.:	25			
	Construction of the American		PULSE AMPLIT	UDE			
Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%	Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%
1 V	11	11	0.9 - 1.1	4 V	4.2 V	4.2 V	3.6 - 4.4
100 mV	100 m V	100 mV	90 - 110	400 mV	420 mV	420 mV	360 - 440
10 mV	10 mV	IOmV	9 - 11	40 mV	42 mV	42 m V	36 - 44
1 mV	1 11		0.9 - 1.1	4 mV	42 V	42 11	3.6 - 4.4

	PULSE FREQU	JENCY (PERIOD)		Reference	As Found	As Left	Acceptable
Pulser	As Found	As Left	Acceptable	Voltage	Voltage Reading	Voltage Reading	Range ± 5%
nge	Period	Period	Range ± 2%	500 V	500	500	475 - 525
x 10K	6.674	6.674	6.534 - 6.8	2000 V	1990	1950	1900 - 2100
x 1K	66.74	66.24	65.34 - 68				
x 100	667.4	667.4	653.4 - 680		As Found	As Left	Acceptable
x 10	6674	6674	6534 - 6800	CPM Reading	cpm Reading	cpm Reading	Range ± 10%
x1	66.75	66.75	65.34 - 68	MAX	992	992	981 - 999
x 0.1	90	90	88.2 - 91.8 Counts	MIN	0-1	0-1	0 - 1*

\* READING OF 0-99 IS ACCEPTABLE FOR INSTRUMENTS WITH A S/N 100000 AND BELOW AND MAIN BOARD = 5208-066

COMMENTS:

Cal'd w/ 39" cable.

Ludium Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. ISO/IE 17025:2005(E)

Reference Instruments:			
Frequency Counter	Model S/N J	1856412450606063Cal Date _3-1	Nov 2016
Oscilloscope	Model 609-6103 S/N_	EP832241 Cal Date 2-	126 2017
Voltmeter	Model Fluke B3 SIN _	94000441 Cal Date 3	May 2017
Trator William Tinal	v Wieliam Timaley	Title Calibrator	Date 5-July 2017
QC'd By	well be -	Title Service Dept OC	Date SJULD

This certificate shall not be reproduced except in full, without the written approval of Ludium Measurements, Inc. FORM SC16-1 12/12/2016 Page \_\_\_\_\_f of \_\_\_\_\_

Model 12241-2

SN 287029

Calibration Source Ludlum Model 500 pulser s# 114513

Threshold (input sensitivity	y), Found at	10	mV	Left or Set at	10	mV
Window, In/Out_N/A	Window	N/A	mV			
Pulser Amplitude Set @	2	0	mV			

Range/Mode	(Pulser Setting) cpm x multiplier	As Found Reading	Left or Set Reading
Ratemeter	40×1	38-40	38-40
	40×10	395-400	395-400
	40×100	3950 - 4000	3950-4000
	40×1K	39K-40K	39K - 40K
Scaler	40×1	40	40
	40×10	398	398
	40×100	3996	3996
	Hoxik	39920	39920

HV Set @ 900 VDC

Calibrated By Julfant Date 8-1-17

ww.ludlums.com	Model No. / S M ENVIRONMENTA	CERTIFIC	ate of calib	RATION	LUDLUM MEA 501 Oak Street 325-235-5494 Sweetwater, TX 79556	U.S.A. 203	CERT # 4084.
Date	5-Jul-17	Cal Due I	Date	5-Jul-18	Cal. Interval 1	Year Procedure	M500. Rev. 5
New Instrur T72 °F	nent Instrument Ri RH4	eceived I Within 1 49_% Alt PULSE WIDTH	Tolerance Out	of Tol. Req	uiring Repair Oth Zeroed Mechan CUSTOMER PO	nical Check	
	As Found	As Left	Accepta Range (	ble µs) ± 10%			
NEG PULSE	1.7	1.7	1.5 -	1.9			
POS PULSE	1.6	1.6	< 2.	25			
		Martin and Antonia and	PULSE AMPLIT	UDE	an a		
Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%	Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%
1 V	11	11	0.9 - 1.1	4 V	4.2 V	4.2 V	3.6 - 4.4
100 mV	100 m V	100 mV	90 - 110	400 mV	420 mV	420 mV	360 - 440
10 mV	10 mV	IOmV	9-11	40 mV	42 m V	42 m V	36 - 44
			0.0.11	4 m)/	112 1	110 .1	36-44

	PULSE FREQU	JENCY (PERIOD)		Reference	As Found	As Left	Acceptable
Puiser	As Found	As Left	Acceptable	Voltage	Voitage Reading	Voltage Reading	Range ± 5%
nge	Period	Period	Range ± 2%	500 V	500	500	475 - 525
x 10K	6.674	6.674	6.534 - 6.8	2000 V	1990	1990	1900 - 2100
x 1K	66.74	66.24	65.34 - 68				
x 100	667.4	667.4	653.4 - 680		As Found	As Left	Acceptable
x 10	6674	6674	6534 - 6800	CPM Reading	cpm Reading	cpm Reading	Range ± 10%
x1	66.75	66.75	65.34 - 68	MAX	992	992	981 - 999
x 0.1	90	90	88.2 - 91.8 Counts	MIN	0-1	0-1	0 - 1*

\* READING OF 0-99 IS ACCEPTABLE FOR INSTRUMENTS WITH A S/N 100000 AND BELOW AND MAIN BOARD = 5208-066

COMMENTS:

Cal'd w/ 39" cable.

Ludium Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. ISO/IE 17025:2005(E)

Reference Instruments:			
Frequency Counter	Model S/N S/N	85641245a6a6a63Cal Date _3-No	V 2016
Oscilloscope	Model 609-6103 S/N_	EP832241 Cal Date 2-1-	6 2017
Voltmeter	Model Fluke B3 I S/N _	94000441 Cal Date 3.97	104 2017
Trator William Tinak	or Wieliam Temples	Title Calibrator	Date 5-Aul 2017
QC'd By R	not be -	Title Service Dent OC	Date SJUID

Scaler/Ratemeter 12221 58#68782 Detector 584-3 # 408522- 30

Source: 1% U308 Can, FCS-1

Strength: 176 4308

Scaler/Ratemeter Threshhold set @ 10 mV, Window IN/OUT Out, Window w/1 mV

HV	Reading, CPM (Source)	Reading, CPM (Background)	Background rea check location i	nding at design n AVM office.	ated function
500	15845	500		Read	ling (CPM)
550	32625	610	Count #	Bare	Collimated
600	54815	1366	1	7711	2945
650	66884	1767	2	7942	2930
700	87428	2329	3	7940	2907
750	92841	2676	4	1862	2963
800	94979	2856	5	7921	2846
850	96047	2927	Average	7875	2918
900	96613	2966	FC Range 4	300-9450	3502-2334
950	97669	3037	Count Readings	with 1 percent	U <sub>3</sub> O <sub>8</sub> can
1000	98213	3168	designated func	tion check local	tion in AVM
1050	106392	3193	office.		
1100	126990	3529	Count #	Reading	(CPM)
1150	152407	4014	1	962	.04
1200	190378	5648	2	959	76
1250			3	966	42
1300			4	964	17
1350			5	966	16
1400			Average	963	71
HV Set @	900	VDC (Instrument)	900	VDC (D	VM Fluke 8020B)

Input Sensitivity (THR), mV 10.0

Function Check with 1 percent  $U_3O_8$  ore in can. Can Directly under the detector in the collimator. Acceptable Function check range is: <u>77097</u> to <u>115645</u> CPM

Notes:

Date 8/1/2017

By T

page 1 of 2

10

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Scaler/Ratemeter <u>2221</u> )	802-20		page 2 of 2
source: Grants DOE Car	Red	Strength:	
Scaler/Ratemeter Threshhold set @ 10	mV, Window IN/OUT	ut, Window NIt	nV
HV Set @ 900	VDC (Instrument)	900	VDC (DVM Fluke 8020B)
Count Readings for Calibration Pad (	GPB (0.0 ± 0.3 pCi/gm Ra-226	0)	
Bare (Uncollin	nated)	Collimated	
#1 12708	cpm #1	2974 cpm	
#2 12-309	cpm #2	2971 cpm	
#3 12411	cpm #3	2186 cpm	
#4 12303	cpm #4	2927 cpm	
#5 12825	cpm #5	3064 cpm	
BKG Average 12511	cpm BKG Average	3025 cpm	
			1 11. 19 + 7124
Count Readings for Calibration Pad	GPL (87.78 nCi/gm Ra-226)		Ludin 17= 12-1
Bare (Uncollin	nated)	Collimated	118/1. 1010
#1 84734	cpm #1	4884/ cpm	Jul Were
#2 85020	cpm #2	49140 cpm	= 110 en/h
#3 85869	cpm #3	48875 cpm	-4
#4 85545	cpm #4	49129 cpm	= 1.29×10
#5 84717	cpm #5	47927 cpm	
Gross Average 85,177	cpm Gross Average	48786 cpm	mayle / CP
Net Source Pad 72666	cpm Net Source Pad	45761 cpm	
Eff(net cpm/s7.78 pCi/gm 828	cpm/pCi/gm Eff	<u>521</u> cpm/p	Ci/gm
			1 00
1		- )/	

Date 8/2/17

By Afat





Scaler/Ratemeter L 2 2 2 1 5R # 68782 Detector 5/4-3, 52 # 408522-33 page 1 of 2 Source: V208 in Saul Can, FCS-1 Strength: 12 U208 Scaler/Ratemeter Threshhold set @ 10 mV, Window IN/OUT out, Window \_\_\_\_ mV Reading, CPM Reading, CPM Background reading at designated function HV (Source) (Background) check location in AVM office. Reading (CPM) Collimated Count # Bare Average 6204-9307 2365-3547 FC Range Count Readings with 1 percent U3O8 can directly under collimated detector on designated function check location in AVM office. Count # Reading (CPM) Average HV Set @ VDC (DVM Fluke 8020B) VDC (Instrument) Input Sensitivity (THR), mV 10.0

Function Check with 1 percent  $U_3O_8$  ore in can. Can Directly under the detector in the collimator. Acceptable Function check range is:  $\frac{768544}{15.2800}$  CPM

Notes:

Date 8/1/2017

By

Scaler/Ratemeter <u>LLZZ</u> Detector <u>SPA-3</u> , SZ 4 4	SR# 68	782		page 2 of 2
Source: Grants DOE Ca	l And.		Strength:	
Scaler/Ratemeter Threshhold set @	10-0 mV, Wi	ndow IN/OUT	Window MA m	v
800		DC (Instrument)	900	VDC (DVM Fluke 8020B)
HV Set @	V.	De (mou unient)		
HV Set @	V	.3 pCi/gm Ra-226)		
HV Set @ <u>700</u> Count Readings for Calibration F Bare (Unc	Pad GPB (0.0 ± 0.	.3 pCi/gm Ra-226)	Collimated	
HV Set @ <u>700</u> Count Readings for Calibration F Bare (Unc #1 1243	Pad GPB (0.0 ± 0. ollimated)	.3 pCi/gm Ra-226) #1	Collimated 2858 cpm	
HV Set @ <u>700</u> Count Readings for Calibration F Bare (Unc #1 <u>1243</u> #2 <u>1213</u>	ad GPB (0.0 ± 0. billimated)	<b>.3 pCi/gm Ra-226)</b> #1	Collimated 2858 cpm 3101 cpm	
HV Set @ <u>700</u> Count Readings for Calibration F Bare (Unc #1 1243 #2 1213 #3 11792	ad GPB (0.0 ± 0. ollimated) cpm cpm cpm	<b>.3 pCi/gm Ra-226)</b> #1 #2 #3	Collimated 2858 cpm 3101 cpm 2957 cpm	
HV Set @ Count Readings for Calibration H Bare (Unc #1 1243 #2 1213 #3 11792 #4 1212	Pad GPB (0.0 ± 0. ollimated) / cpm cpm cpm cpm cpm	<b>.3 pCi/gm Ra-226)</b> #1 #2 #3 #4	Collimated 2858 cpm 3/0/ cpm 2957 cpm 3002 cpm	
HV Set @ Count Readings for Calibration F Bare (Unc #1 1243 #2 1213 #3 11792 #4 1212 #5 1240	ad GPB (0.0 ± 0. bilimated) cpm cpm cpm cpm cpm cpm cpm	<b>.3 pCi/gm Ra-226)</b> #1#2 #3 #4	Collimated 2858 cpm 3101 cpm 2957 cpm 3002 cpm 2981 cpm	

Count Readings for Calibration Pad GPL (87.78 pCi/gm Ra-226)

	Bare (Uncollin	nated)
#1	85603	cpm
#2	84954	cpm
#3	84970	cpm
#4	84065	cpm
#5	84777	cpm
Gross Average	84874	cpm

#1	Collimated 48752	, cpm
#2	48188	cpm
#3	47791	cpm
#4	48653	cpm
#5	48694	cpm
Gross Average	48416	cpm

Net Source Pad 72697 cpm Effinet cpm/s7.78 pCi/gm 828 cpm/pCi/gm

Net Source Pad 45436 cpm Eff 578 cpm/pCi/gm

By

Exiso sure Rate Ludlue 19 # 7628 01.0' 110 eng/h = 1. 2.96×10-4 Me/m/com

Date 8/2/17



**Background Counts per Minute** 

## Detector High Voltage Plateau SPA-3 #408522-33 with Ludlum 2221 #68782 1% Uranium Ore in Sealed Can August 1, 2017

Source Plateau — Background Plateau — Poly. (Source Plateau)

Scaler/Ratemeter <u>L 2221</u>, SR # 68782 Detector <u>SPA-3</u>, SR # 10071 Source: 16 Vals in Seal Ban \* FCS-1

Reading, CPM

page 1 of 2

Strength: 120 Uzar are

Scaler/Ratemeter Threshhold set @ 100 mV, Window IN/OUT Out, Window N/A mV

Reading, CPM Background reading at designated function (Background) check location in AVM office.

HV	(Source)	(Background)	check location	in AVM office.	
500	9145	477		Read	ing (CPM)
550	27944	844	Count #	Bare	Collimated
600	45954	1210	1	7924	2705
650	59667	1631	2	7737	2757
700	72178	2128	3	7935	2728
750	84117	2322	4	7789	2821
800	87565	2483	5	7799	2746
850	89707	2644	Average	7837	2757
900	90363	2624	FC Range 4	270-9405	2201-3302
950	90191	26.48	Count Reading	gs with 1 percent	U <sub>3</sub> O <sub>8</sub> can
1000	90456	2740	designated fur	committee detec	ion in AVM
1050	91634	2802	office.		
1100	10/193	2964	Count #	Reading (	CPM)
1150	128133	3444	1	9074	7
1200	184347	4950	2	9049	0
1250			3	9006	3
1300			4	9095	4
1350			5	8978	8
1400			Average	90413	
			002	72330 - 1	108495
HV Set @	900	VDC (Instrument)	900	VDC (D)	M Fluke 8020B)

Input Sensitivity (THR), mV 10.0

Function Check with 1 percent  $U_3O_3$  ore in can. Can Directly under the detector in the collimator. Acceptable Function check range is: 72330 to 108495 CPM

Notes:

Date 8/1/2017

By fat

Scaler/Ratemeter						page 2 of 2
Detector SPA-3,	SP# 1007	1				
Source: Grants	DOE OR	bd		Strength:	GPB	GPL
Scaler/Ratemeter Thresh	nhold set @ 10.2	_mV, Window IN/0	DUT Ou	t, Window	MAT	7
HV Set @ 900		VDC (Instru	ument)	900		VDC (DVM Fluke 8020B)
Count Readings for Ca	alibration Pad GI	PB (0.0 ± 0.3 pCi/gm	Ra-226)	Collimated		
#1	11 559	nm	#1	9930	com	
#2	11844	pm	#2	2861	com	
#3	12203 0	Dm	#3	2775	cpm	
#4	11655 0	pm	#4	2740	cpm	
#5	12078 0	pm	#5	2704	cpm	
BKG Average	11934 0	pm BKG A	verage	2802	cpm	
Count Readings for Ca	alibration Pad GF	PL (87.78 pCi/gm Ra	a-226)	Callimated		Exposue Ra
#1	Sare (Uncollina	nm	#1	46561	com	/ udlen 19 \$ 70

#1	82822	cpm
#2	82312	cpm
#3	82365	cpm
#4	82446	cpm
#5	83105	cpm
Gross Average	82610	cpm

Collimated #1 46561 cpm #2 45525 cpm #3 46195 cpm #4 46243 cpm #5 46256 cpm Gross Average 46165 cpm

Exposue Pate Lade 19# 76288 @ 110' ere/hu = 110 ere/hu = 1.33 re/h/ci

Net Source Pad 43363 Eff 494 Net Source Pad 70 67 6 cpm Effinet cpm/s7.78 pCi/gm 505 cpm/pCi/gm

By Tat Port

\_\_\_\_ cpm \_\_\_\_\_ cpm/pCi/gm

Date 8/2/17



## Detector High Voltage Plateau SPA-3 #10071 with Ludlum 2221 #68782 1% Uranium Ore in Sealed Can August 1, 2017

Source Plateau Background Plateau

## **AVM Environmental Services Inc.** L2221 SCA/L44-20 Energy Calibration Form

SCA: L2221, SR #68782

Detector: Ludlum 44-20 (3x3 NaI Scintillator)

Calibration Source: Cs-137 Check Source, 5 uCi (August 2008) For 662 KeV Peak Cal

Threshold (input sensitivity 652
Window, In/Out IN Window 20
HV Initial 100, At Peak 590
Maximum CPM: 189,640 Background CPM: 7
HV Set @ 590 VDC
For Bi-214 609.2 KeV Peak (559 - 659 KeV ROI), Set Threshold @ 559. Window @ 100
Calibration Check w 1% U3O8 Ore Check Source: 16157 CPM Blook 71
Date 04-14-2018 Calibrated By

AVM Environmental Services Ex-Situ Soil Screening Gamma Radiation Level to Ra-226 Correlation St Anthony Mine Site Test Pit Investigation

Reference Soil ID	Date	Ra-226 pCi/g	Wtgms	609 KeV CP5Min Gross (3x3 Nal Detector)	CPM
Blank	4/14/2018	0	-	389	78
BKG Soil	4/14//18	1	3000	1522	304
SA Ref Soil	4/14//18	6.6	3000	3392	678
NECR PTW Ref Soil	4/14//18	100	3000	41400	8280



0.999887918 0.999775848

Multiple R R Square

**Regression Statistics** 

SUMMARY OUTPUT

0.999663772 0.895185294

Adjusted R Square Standard Error Observations

-
-
$\mathbf{O}$
-
~
1

	df	SS	MS	F	Significance F
Regression	1	7148.517287	7148.517287	8920.518403	0.000112082
Residual	2	1.602713422	0.801356711		
Total	3	7150.12			

			and the second se					
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-1.80557978	0.541028323	-3.33731101	0.079258065	-4.13343677	0.522277213	-4.13343677	0.522277213
X Variable 1	0.01229282	0.000130154	94.44849604	0.000112082	0.011732814	0.012852827	0.011732814	0.012852827
AVM Eavi. Jetal Services, Inc. Field Soil Sample Gamma Radiation Screening Form St. Aathony Mine Site

Instrumentation : Scaler/Ratemeter [2721 (#240862), Detector <u>h. 44-20 (</u>#295573) Instrument Calibration Date: 04-14-2018, Instrument Function Check Performed: Y , Instrument Function Check Performed: le mente 0 Survey Area/Unit Decsription Contelectu

Date/Time	Soil Sample ID	Sample Weight Grams	609 (559-669) Kev Gross Counts	Weight Corrected Counts	CPM	Estimated Ra- 226 pCi/g	Comments	
Hury 8	Clark	١	389	١	36	Ø		
4-14-18	St. Antry Bankgroud Soil	3000	1522	ł	tos	0.1		
81-14-18	St. Anthing 6.6 PCilg Refame Soli	3000	3392	,	678	6.6		
オーウトト	100 fils Reference Soil	3000	agh 14	١	8280	100		
								•
								1
		1						
Technician Sign	wature Reviewed by	2~N	X					

	of Scientific and industrial Instruments	CERTIFIC	ATE OF CALIBRATION	LUDLUM MEAGORE 501 Oak Street 325-235-5494 Sweetwater, TX 79556, U.S.A.	ACCREDITED CERT # 4084.01
Customer	AVM ENVIRONMENTAL SE	RVICE8		ORDER NO	20314714/451653
MA	Ludium Measurements, Inc	Model	19	Serial No. 76	248
N		Model		Serial No.	
Cal. Date	5-Jul-17	Cal Due Date	5-Jul-18	Cal. Interval <u>1 Year</u> Met	erface 202-016
heck mark	Applies to applicable instr. a	nd/or detector IAW mi	fg. spec. T. 72	*F RH 48 %	Alt707.0 mm Hg
New Ins	trument Instrument Rece	wed PWithin Tok	er. +-10% 🔲 10-20% 🗌 Out of	Tol. Requiring Repair	Other-See comments
F/S Res Audio cl	icalck. ip. ck k. A	Aeter Zeroed Reset ck. Narm Setting ck.	Background Subtra Window Operation Batt. ck.	ict Input S	ens. Linearity pism
Calibrate	d in accordance with LMI SOF	14.8	Calibrated in accord	ance with LMI SOP 14.9	
nstrument Voi	it Set V Inpu	t Sens n	NV Det. OperV	at mV Dial Ratio	=
	Readout (2 points) Ref./In	st. <u>500</u>	/V R	tef./inst1200 //	v
COMMENT	Te.				

COMMENTS:

	RANGE/MULTIPLI	ER C	EFERENCE	· IN	S FOUND READ	C'D	INSTRUM	
$\cap$	5000	4000	IR/hr		4000		TWIGHT I MAT & F	4000
	5000	1000	R/hr	-	1000			IDAD
	500	400 uF	Inr = 73 110 CPM	-	400			400
	500	100	R/hr		100			100
	250	200 uF	Uhr = 37560 CPM	-	200			200
	250	100 1	uR/hr		100			100
	50	7300	cpm		40			40
	50	1825	cpm	_	10			10
	25	3750	cpm		21			20
	25	937	cpm	-	5			5
	*Uncertainty within ± 10% C	.F. within ± 20%				50, 25	Range(s) Cal	Ibrated Electronically
	REFERENCE	INSTRUMENT	INSTRUMENT		REFERENCE	INS	TRUMENT	INSTRUMENT
	CAL. POINT	RECEIVED	METER READING*		CAL. POINT	REC	EIVED	METER READING*
Digital				DOL				
Readout				Scale				
						-		
						-		
Ludium Meas other internat	urements, Inc. certifies that the abo tional Standards Organization memb	ve instrument has been o bers, or have been derive	calibrated by standards traceable to ad from accepted values of natural p	the Nation	nal Institute of Standards and Instants or have been derived	Technolog by the rati	y, or to the calibration	on facilities of techniques.
The calibratio	an system conforms to the requirement	ents of ANSI/NCSL Z540	-1-1994 and ANSI N323-1978	ISO/IE	17025:2005(E)	State	of Texas Calibra	tion License No. LO-1963
Referenc	e instruments and/or Source	e: Ce-137 S/N: 059	2171CP 2261CP 720	734	781 1131 1	616	1896 1909	1916CP 2324/2521
5717C	0 0 5719CO 0 60646 0	70897 73410	E552 G112 2168CP	8-394	8-1064 T10081	T10082	Neutron Am-241 Be	T-304 Re-226 Y98
5717C	o _ 5719CO _ 60646 _ ; oha S/N	70897 73410	E552 [] G112 [] 2168CP [] ] Beta S/N	8-394	<b>8-1054 T10081</b>	Other	Neutron Am-241 Be	T-304 Re-226 Y98
6717C	o [] 5719CO [] 60846 [] ; oha S/N 500 S/N	70897 []73410 [] [] 9 []	E552 G112 2168CP Beta S/N	3-394	8-1064 T10081	Other Multime	tar S/N	71300492
	o 🗋 5719CO 🗌 60846 📑 pha S/N 500 S/N18950		E552 G112 2168CP Beta S/N Oscilloscope S/N	3-394		Other Multime	Neutron Am-241 Be	71300492
Alr Alr Alr	o [] 5719CO [] 60846 [] ; oha S/N 500 S/N18950 orWENDELL WILLIAM:	10867 [73410 ] 9 [ 5 Vandell W	E552 G112 2168CP C Beta S/N Oscilloscope S/N GMMM* Title _	] 8-394 Calib	□ 8-1054 □ T10081 □ □ 	T10082 Other Multime	ter S/N Date _5	71300492 <i>Jul 1</i> 7
GC'd By	o     5719C0     60846     3       oha S/N	9 Company Comp	E552 G112 2168CP C Beta S/N Oscilloscope S/N Cultur Title Title	Callb	8-1054     T10081       Image: second	Other Multime	ter S/N Date <u>5</u> Date	71300492 71300492 Joh 17
GC'd By	0     5719C0     60846     1       50ha S/N	e Contraction Cont	E552 G112 2168CP Beta S/N Oscilloscope S/N ////////////////////////////////	] 8-394 <u>Calib</u> S		Other Multime	ter S/N Date <u>5</u> Date	71300492 <u>Jek 17</u> <u>Jul 17</u>

Meter: Manufactur	er: Ludlum	Model Number:	2221r	Serial Number:	262325
Detector: Manufactur	er: Ludhum	Model Number:	44-10	Serial Number:	PR150851
<ul> <li>Mechanical Check</li> <li>F/S Response Check</li> <li>Geotropism</li> <li>Meter Zeroed</li> <li>Source Distance: Co</li> <li>Source Geometry: Si</li> <li>Instrument found with</li> </ul>	<ul> <li>✓ THR/WIN Oper</li> <li>✓ Reset Check</li> <li>✓ Audio Check</li> <li>✓ Battery Check (</li> <li>mtact ✓ 6 inches □</li> <li>de □ Below □</li> <li>hin tolerance: ✓ Ye</li> </ul>	ration H Ca Min 4.4 VDC) Other: T Other: T s No	V Check (+/- 2.5%) able Length: 3 hreshold: 10 mV Window:	e: 2 500 V 2 100 9-inch 2 72-inch Barometric Press Temperat Relative Humi	0 V ☑ 1500 V ☐ Other: sure: 24.51 inches Ha aure: 76 °F dity: 20 %
Range/Multiplier	Reference Setting	"As Found Reading	" Meter Rea	Integ	grated Count Log Scale Co
x 1000	400	400	400	39	9130 400
x 1000	100	100	100		100
x 100	400	400	400	39	919 400
x 100	100	100	100		100
x 10	400	400	400	3	993 400
x 10	100	100	100		100
x 1	400	400	400		400
<b>x</b> 1	100	100	100		100
High Voltage	Source Count	s Back	ground	Ve	oltage Plateau
800         900         950         1000         1050         1100         1150         1200         1250	30457 51582 58317 63521 65877 67461 69361 70973 71665		131	80000 70000 60000 50000 40000 30000 20000 10000 0	9 189 119 129
Reference Instruments Ludium pulser serial nu Alpha Source: Th-2 Beta Source: Th-9 ibrated By:	s and/or Sources: mber: 97743 2 2 30 sn: 4098-03@12,80 9 sn: 4099-03@17,700	201932 20dpm/6,520 cpm (1/4/12 20dpm/11,100cpm(1/4/12 20dpm/11	Fluke multim 12) $\Box$ Gamma So 2) $\Box$ Other Sou ion Date: $3 - 1 - 1 - 1$	eter serial number: [ ource Cs-137@5.2 rce: Calibration	]87490128 uCi (1/4/12) sn: 4097-03 n Due: <u>3-14-19</u>
viewed By:	h	Date:	03/14/18		

**Certificate of Calibration** 

**Calibration and Voltage Plateau** 

ERG

Environmental Restoration Group, Inc. 8809 Washington St NE, Suite 150 Albuquerque, NM 87113 (505) 298-4224

www.ERGoffice.com

www.ludiums.com	of Scientific and Industrial Instruments	CERTIF	ICATE OF CALIBRATI	ON 501 Oak Street 325-235-5494 Sweetwater, TX 79	556, U.S.A.	ACCREDITED CERT # 4084.01
Customer	AVMENVIKONMENTA	L SERVICES			ORDER NO. 203	314714/451653
MD	Ludium Measurement	s, Inc. Model	19	Serial	No. 1627	8
N		Model		Seria	No	
Cal. Date	5-Jul-17	Cal Due Date	5-Jul-18	Cal. Interval	1 Year Meterface	202-016
Check mark	Applies to applicable in	str. and/or detector IAW	/ mfg. spec. T	72 °F RH	48 % Alt	707.0 mm Hg
New Ins	trument Instrument	Received Within	Toler. +-10% [] 10-20% []	Out of Tol. 🔲 Requirir	ng Repair 🔲 Other-	See comments
F/S Res	ical ck. p. ck k.	Meter Zeroed Reset ck.	☐ Background ☐ Window Ope ✔ Batt. ck.	Subtract ration	☐ Input Sens. L ☑ Geotropism	inearity
Calibrate	d in accordance with LMI	SOP 14.8	Calibrated in a	accordance with LMI SC	P 14.9	
Instrument Vol	t Set 850 V	input Sens37	mV Det. Oper.	V atr	Threshold nV Dial Ratio	= mV
	Readout (2 points) R	tef./inst. 500	/	V Ref./Inst.	1200 /	V
COMMENT	re.					

	RANGE/MULTIPLI	ER C	EFERENCE AL. POINT	INSTRUMENT REC "AS FOUND READ	C'D ING"	INSTRUM METER F	MENT READING*
$\cap$	5000	4000	uR/hr	4000			4000
~	5000	1000	uR/hr	1000			1000
	500	400 uF	2/hr = 73110 CPM	400			400
	500	100	uR/hr	100			100
	250	200 uF	2/hr = 37560 cpm	200			200
	250	100	uR/hr	100			100
	50	7300	cpm	40			40
	50	1825	cpm	10			10
	25	3750	cpm	20			20
	25	937	cpm	.5			5
	*Uncertainty within ± 10% C.	F. within ± 20%			50, 25 R	ange(s) Cal	ibrated Electronically
	REFERENCE I	NSTRUMENT	INSTRUMENT	REFERENCE	INSTRU	JMENT	INSTRUMENT
	CAL. POINT	RECEIVED	METER READING*	CAL. POINT	RECEN	VED	METER READING*
Digital				og			
Readout			S	cale			
Ludium Mear	urements, Inc. certifies that the abov	e instrument has been	calibrated by standards traceable to th	e National Institute of Standards and	Technology, or	to the calibratio	on facilities of
other Internet	tional Standards Organization memb	ers, or have been deriv	ed from accepted values of natural phy	ysical constants or have been derived	by the ratio typ	e or calibration	techniques.
other Interne The calibratic	tional Standards Organization memb	ers, or have been deriv.	ed from accepted values of natural ph -1-1994 and ANSI N323-1978	vslcal constants or have been derived	by the ratio typ State of	Texas Calibra	techniques. tion License No. LO-1963
Reference	tional Standards Organization memb on system conforms to the requirements ce Instruments and/or Sources	ers, or have been deriv nts of ANSI/NCSL Z540 I: Ce-137 S/N: 059	ed from accepted values of natural ph >1-1994 and ANSI N323-1978 2171CP 2261CP 720 E552 G112 2188CP	ysical constants or have been derived ISO/IE 17025:2005(E) 734 761 1131 1 S-394 8-1054 70081	State of           616         1696           T10082         Next	Texas Calibra	techniques. tton License No. LO-1963 1916CP 2324/2521
other Interne The calibratic Reference 5717C	tional Standards Organization memb on system conforms to the requirements is instruments and/or Sources 0 5719C0 60646 77	ers, or have been deriv nts of ANSI/NCSL Z540 1: Ce-137 S/N: 059 0897 73410	ed from accepted values of natural ph >1-1994 and ANSI N323-1978 2171CP 2261CP 720 E552 G112 2168CP	ysical constants or have been derived ISO/IE 17025:2005(E) 734 781 1131 1 S-394 S-1054 T10081	by the ratio typ State of 616 1696 T10082 Neut	Texas Calibration 1909 [ ron Am-241 Be	techniques. (tion License No. LO-1963 ] 1916CP [] 2324/2521 [] T-304 Re-226 [] Y98;
other Interna The calibratic Reference 5717C	tional Standards Organization memb in system conforms to the requireme ce Instruments and/or Sources 0 5719C0 80846 7 oha S/N	ers, or have been deriv nts of ANSI/NCSL Z54( : Ce-137 S/N: 059 0897 73410	ed from accepted values of natural ph >-1-1994 and ANSI N323-1978 2171CP 2261CP 720 E552 G112 2168CP Beta S/N	ysical constants or have been derived ISO/IE 17025:2005(E) 734 781 1131 1 S-394 S-1054 T10081 	by the ratio typ State of 616 1698 T10082 Neut Other	Texas Calibra [] 1909 [ ron Am-241 Be	techniques. (flon License No. LO-1963 ] 1916CP [] 2324/2521 [] T-304 Ra-226 [] Y98;
Reference 5717C	tional Standards Organization memb on system conforms to the requirements a <b>Instruments and/or Source</b> 0 5719C0 60846 7 bha S/N 500 S/N	ers, or have been deriv nts of ANSI/NCSL Z54( b: Ce-137 S/N: 059 0697 73410	ed from accepted values of natural ph >-1-1994 and ANSI N323-1978 2171CP 2261CP 720 E552 G112 2168CP 3 Beta S/N Oscilloscope S/N	ysical constants or have been derived ISO/IE 17025:2005(E) 734 781 1131 1 S-394 8-1054 T10081 	by the ratio typ State of 616 1696 T10082 Neut Other Multimeter	ron Am-241 Be	techniques. tion License No. LO-1963 ] 1916CP [] 2324/2521 [] T-304 Re-226 [] Y98; 71300492
Aligned Aligne	tional Standards Organization memb on system conforms to the requirements is instruments and/or Sources 0 5719C0 60846 77 oha S/N 500 S/N 189506	ere, or have been deriv nts of ANS//NCSL Z54/ 1: Ce-137 S/N: 059 0897 73410 	ed from accepted values of natural ph >1-1994 and ANSI N323-1978 2171CP 2261CP 720 E552 G112 2168CP Beta S/N Oscilloscope S/N	ysical constants or have been derived ISO/IE 17025:2005(E) 734 781 1131 1 S-394 S-1054 T10081 	by the ratio typ State of 616 1696 T10082 Neut Other Multimeter	ron Am-241 Be	techniques. (tion License No. LO-1963 ] 1916CP [] 2324/2521 [] T-304 Re-226 [] Y98; 71300492
Cher Interna The calibratic Reference 5717C	tional Standards Organization memb on system conforms to the requirements and/or Sources o 5719CO 60848 77 oha S/N 189509 500 S/N 189509 or WENDELL WILLIAMS	ere, or have been deriv nte of ANSUNCSL Z54( 1: Ce-137 S/N: 059 0897 73410 	ed from accepted values of natural ph D-1-1994 and ANSI N323-1978 2171CP 2261CP 720 E552 G112 2168CP 3 Beta S/N Oscilloscope S/N WMMM` Title	yalcal constants or have been derived ISO/IE 17025:2005(E) 734 781 1131 1 S-394 8-1054 710081 Calibrator	by the ratio typ State of 616 1696 T10082 Neut Other Multimeter	e or calibration Texas Calibra 1909 [ ron Am-241 Be S/N Date 5	techniques. tion License No. LO-1963 ] 1916CP [] 2324/2521 [] T-304 Re-226 [] Y98 71300492 J_K / 7
All	tional Standards Organization memb n system conforms to the requirements and/or Sourcest o 5719C0 60846 7 oha S/N 500 S/N 500 S/N WENDELL WILLIAMS	ere, or have been deriv nite of ANSI/NCSL Z54( 1: Ce-137 S/N: 059 0897 73410 [] 	ed from accepted values of natural ph D-1-1994 and ANSI N323-1978 2171CP 2261CP 720 E552 G112 2168CP 3 Beta S/N Oscilloscope S/N ////////////////////////////////	yalcal constants or have been derived ISO/IE 17025:2005(E) 734 2781 1131 1 s-394 \$-1054 T10081 Calibrator Service Dept (	by the ratio typ State of 816 1896 T10082 Neut Other Multimeter	e or calibration Texas Calibra 1909 [ ron Am-241 Be S/N Date Date	techniques. tion License No. LO-1983 ]1918CP [] 2324/2521 [] T-304 Ra-226 [] Y98: 71300492 Лид / 7 JULIJ
Cher Interna The calibratic Reference 5717C All All Comment QC'd By	tional Standards Organization memb on system conforms to the requirements to Instruments and/or Sources 0 5719C0 60848 7 oha S/N 500 S/N 500 S/N 0r WENDELL WILLIAMS	ere, or have been deriv nte of ANSUNCSL Z540 1: Ce-137 S/N: 059 0897 73410 [ 	ed from accepted values of natural ph D-1-1994 and ANSI N323-1978 2171CP 2261CP 720 E552 G112 2168CP Beta S/N Oscilloscope S/N ////////////////////////////////	yalcal constants or have been derived ISO/IE 17025:2005(E) 734 781 1131 1 S-394 S-1054 T10081 Calibrator Service Dept (	by the ratio typ State of 616 1696 T10082 Neut Other Multimeter	e or calibration Texas Calibra 1909 [ ron Am-241 Be S/N Date Date	techniques. (fon License No. LO-1963 ] 1916СР [] 2324/2521 [] T-304 Re-226 [] Y983 71300492 Лик / 7 JUN ()

	of Scientific and industr instruments	ial .	CERTIFICA	te of C	CALIBRATIO	V 501 Oak Stra 325-235-549 Sweetwater,	et 4 TX 79556, U.	SA.	CERT	200) ccRibert D # 4084.01
Customer	AVM ENVIRONMEN	ITAL SERVICES	3				ORDE	R NO.	20314714/45	1653
Man-	Ludium Measurem	ents, Inc.	Model		19		Serial No.	162	48	
N			Model				Serial No.			
Cal. Date	5-Jui-1	7 Cal	Due Date		5-Jul-18	Cal. Interva	1 <u>1 Ye</u>	ar Meterfa	ce	202-016
Check mark	Applies to applicabl	e instr. and/or de	stector IAW mfg	spec.	Т	72 °F	RH	48 % Alt	707.0	mm Hg
New Ins	strument Instrume	nt Received	Within Toler	. +-10%	] 10-20% 🗌 Ou	t of Tol.	equiring Rep	air Othe	-See comm	ients
Mechan	ical ck.	Meter Ze	roed		Background Sul	btract	Г	Input Sens	. Linearity	
F/S Rea	sp. ck	Reset ck			Window Operat	lon	5	Geotropisn	n	
Audio c	ĸ.	Alarm Se	tting ck.		Batt. ck.					
Calibrate	d in accordance with I	MI SOP 14.8		14	Calibrated in acc	ordance with L	MI SOP 14.	9		
Instrument Vo	it Set 850	V Input Sens.	m\	Det. Ope	r	Vat	mV	Threshold Dial Ratio	=	mV
	Readout (2 points)	Ref./Inst.	500	_/	v	Ref./Inst.	1200	/		v
COMMEN	TS:				the first state of the state of					

Gamma Calibration:	GM detectors po	sitioned perpend	ticular to source	except for M	44-9 in which t	the front of pr	obe faces source.

	RANGE/MULTIPLIE	REFE CAL.	POINT	11	STRUMENT REAL	C'D DING"	INSTRUM METER F	MENT READING*	
$\cap$	5000	4000 uR/h	r		400	0		4000	
~	5000	1000 uR/h	r		100	2		1000	
	500	400 uR/hr :	= 73000 CPM	n _	400	,		400	
	500	100 uR/h	r		100			100	
	250	200 uR/hr =	= 37560 CPM	7 _	200			200	
	250	100 uR/h	r		100			100	
	50	<u>7300 cpn</u>	n		40			40	
	50	1925 cpn	n	_	10			10	
	25	37.50 cpm	n		20			20	
	25	937 cpn	n		5			5	
	*Uncertainty within ± 10% C.I	F. within ± 20%				50, 25	Range(s) Cal	Ibrated Electronica	lly
-	REFERENCE IN CAL. POINT R	ECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INST	RUMENT	INSTRUMENT METER READ	ING*
Jigital Readout				Scale					_
udium Measu ther Internation	rements, Inc. certifies that the above onal Standards Organization membe system conforms to the requirement	instrument has been calibra rs, or have been derived from ts of ANSI/NCSL 2540-1-199	ted by standards traceable to accepted values of natural 4 and ANSI N323-1978	o the Natio physical c ISO/IE	nal institute of Standards ar Instants or have been deriv 17025:2005(E)	d Technology, ed by the ratio t State c	or to the calibration ype of calibration of Texas Calibra	on facilities of techniques. tion License No. LO-19	63
Reference	Instruments and/or Sources     5719C06084670	: Ce-137 S/N: 059 21: 697 73410 E552	71CP 2281CP 720	0 <b>73</b> 4	2781 1131 5 8-1064 710081	1616 161	96 1909 utron Am-241 Be	] 1916CP 2324/2521	] Y982
	ha S/N	Bi	eta S/N			Other			
🗹 m 5	00 S/N 189509		cilloscope S/N			Multimete	r S/N	71300492	
6reto		Warfell War	him. Title	Calib	rator		Date 5	Jul 17	
QC'd By	Phot	1.	Title	S	ervice Dept	QC	Date 5	JUID	
This certific FORM SC2	ate shall not be reproduced except in 12A 12/12/2016 Page	full, without the written appr 	oval of Lucium Measurement	ts, Inc.	AC Inst. Only	Pessed Failed:	Dielectric (Hi-P	ot) and Continuity Test	

www.ludiums.com Customer	Of Scientific and Industrial Instruments	CERTIF	ICATE OI	F CALIBRATION	Sol Oak Street 325-235-5494 Sweetwater, TX 7	9556, U.S.A. ORDER NO	CERT 20314714/45	CCREDITED # 4084.01 1653
Man-	Ludium Measuremen	nts, Inc. Model		128	Seri	al No	1090	
N	3	Model			Seri	al No.		
Cal. Date	5-Jul-17	Cal Due Date		5-Jul-18	_ Cal. Interval	1 Year Me	eterface	X4
Check mark	Applies to applicable i	instr. and/or detector IAW	mfg. spec.	Т7	2 °F RH_	48 %	Alt707.0	mm Hg
New Inst	trument Instrument	Received DWithin	Toler. +-10%	10-20% Out	of Tol. 🗌 Requi	ing Repair	Other-See comm	ents
F/S Res	ical ck. p. ck c.	Meter Zeroed Reset ck. Alarm Setting ck.		Background Sub Window Operation	tract	Input Geotr	Sens. Linearity opism	
Calibrated	d in accordance with LN	I SOP 14.8		Calibrated in acco	ordance with LMI S	OP 14.9		
Instrument Vol	t Set750 V	Input Sens. 37	_mV Det.	Oper	Vat	mV Dial Ratio	a	mv
	Readout (2 points)	Ref./Inst	/	v	Ref./Inst	/	·	V

CO		TC.
CO	NALVA	13.

	RANGE/MULTIPLI	RE ER CA	FERENCE	IN:	STRUMENT RE	C'D DING"	INSTRU	MENT READING*
$\cap$	X 1000	2000 u	R/hr		21			2
	X 1000	1000 u	R/hr		111			1
	X 100	200 uR	hr = 35000 cpm		2			2
	X 100	100 u	R/hr		1			1
	X 10	3500	com		2			2
	X 10	1750	com		1			1
	x 1	350	com		2			2
	<u>x 1</u>	175	cpm		Ĩ			1
	*Uncertainty within ± 10% C.	F. within ± 20%				X10, X1	Range(s) Ca	librated Electronically
	REFERENCE	NSTRUMENT	INSTRUMENT		REFERENCE	INST	RUMENT	INSTRUMENT
	CAL POINT F	RECEIVED	METER READING*		CAL POINT	REC	EIVED	METER READING*
Digital	ORE. POINT		METERINEADING	1.00	ONL. I ONTI			
Readout				Scale				
Ludium Meas other Internat The calibratio	turements, Inc. certifies that the abov tional Standards Organization membron system conforms to the requirement	e Instrument has been o ers, or have been derive nts of ANSI/NCSL Z540-	alibrated by standards traceable to d from accepted values of natural j 1-1994 and ANSI N323-1978	the Nationa physical con ISO/IE 1	al Institute of Standards ar Istants or have been derive 7025:2005(E)	d Technology, ed by the ratio State	or to the calibration type of calibration of Texas Calibration	ion facilities of h techniques. ation License No. LO-1963
Reference	e Instruments and/or Source	8: Ca-137 6/N: 059	2171CP 2281CP 720	734	781 1131 5-1054 T10081	1616 16 T10082 N	96 [] 1909 [ autron Am-241 Be	1916CP 2324/2521
	oha S/N		Beta S/N			Other		
m 🗹	500 S/N 189509		Oscilloscope S/N			Multimete	er S/N	71300492
L. Jrate		wender h	utur Title	Calibra	ator		Date 5	Juh 17
	01.	V1 .		Ser	vice Dept C	C	Date S	1112
QC'd By	mark						Date	2011

	Model No. /	CERTIFIC/ Serial No500	ATE OF CALIB	RATION	501 Oak Street 325-235-5494 Sweetwater, TX 79556	. U.S.A.	CERT # 4084.0
Customer AN	M ENVIRONMENTA	L SERVICES			0	RDER NO. 2031	4713/451652
Jate	5-Jul-17	Cal Due D	Dete	5-Jul-18	Cal. Interval	Year Procedure	M500. Rev. 5
New Instru T72 •	F RH	teceived I Within 1	olerance Out o	of Tol. Req	uiring Repair 🛛 Ott Zeroed 🗹 Mecha	nical Check	
		PULSE WIDTH				MA	
	As Found	As Left	Accepta Range (j	ble µs) ± 10%			
NEG PULSE	1.7	1.7	1.5 -	1.9			
POS PULSE	1.6	1.6	< 2.:	25			
			PULSE AMPLIT	UDE			
Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%	Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%
1 V	11	11	0.9 - 1.1	4V	4.2 V	4.2 V	3.6 - 4.4
100 mV	100 mV	100 mV	90 - 110	400 mV	420 mV	420 mV	360 - 440
10 mV	10 mV	IOnV	9 - 11	40 mV	42 mV	42 m V	36 - 44
1 mV	Inv	Inv	0.9 - 1.1	4 mV	4.2 mV	4.2 mV	3.6 - 4.4
	PULSE FRE	QUENCY (PERIOD)		Reference	As Found	As Left	Acceptable

Pulser	As Found	AS LET	Acceptable				
nge	Period	Period	Range ± 2%	500 V	500	500	475 - 525
( 10K	6.674	6.674	6.534 - 6.8	2000 V	1990	1990	1900 - 2100
x 1K	66.74	66.74	65.34 - 68				
x 100	667.4	667.4	653.4 - 680		As Found	As Left	Acceptable
x 10	6674	6674	6534 - 6800	CPM Reading	cpm Reading	cpm Reading	Range ± 10%
x1	66.75	66.75	65.34 - 68	MAX	992	992	981 - 999
x 0.1	90	90	88.2 - 91.8 Counts	MIN	0-1	0-1	0 - 1*

\* READING OF 0-99 IS ACCEPTABLE FOR INSTRUMENTS WITH A S/N 100000 AND BELOW AND MAIN BOARD = 5208-066

## COMMENTS:

Cal'd w/ 39" cable.

Ludium Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National institute of Standards and Technology. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. ISO/IE 17025:2005(E)

Reference Instruments:				
Frequency Counter	Model S/N S/N	185641245a666063Cal Date	3-Nov 2016	
Oscilloscope	Model 608-6103 SN _	EP832241 Cal Date	2-126 2017	
Voltmeter	Model Fluke B3 SIN -	94000441 Cal Date	3. May 2017	
Trator William Tinele	v 2. Dialiam Temaleu	Title Calibrator	Date <u>5.1</u>	An 2017
acd By Re	as he -	Title Service Den	t OC Date ST	54117

This certificate shall not be reproduced except in full, without the written approval of Ludium Measurements, inc. FORM SC16-1 12/12/2016 Page \_\_\_\_\_f of \_\_\_\_\_



# CERTIFICATE OF CALIBRATION

Electroplated Beta Standard

S	.0		#_	6233	
P	.0	•	ŧ	1093	

Description of Standard:

Model No	DNS-14	Serial	No.	442-05		Isotope	SrY-90		
Electroplated	on polished_	Ni		disc,	0.79			mm	thick.
Total diamete	r of 4	.77	cm and a	n active	diamet	er of	4.45		cm.

The radioactive material is permanently fixed to the disc by heat treatment without any covering over the active surface.

### Measurement Method:

The 2pi beta emission rate was measured using an internal gas flow proportional chamber. Absolute counting of beta particles emitted in the hemisphere above the active surface was verified by counting above, below, and at the operative voltage. The calibration is traceable to NIST by reference to an NIST calibrated beta source S/N = 4002-02.

#### Measurement Result:

The observed beta count rate from the surface of the disc per minute (cpm) on the calibration date was:

3,050 + 122

The total disintegration rate (dpm) assuming <u>40</u> % backscatter of beta particles from the surface of the disc, was:

4,370 + 174 (\_\_\_\_\_0.00197 μC1)

The uncertainty of the measurement is 4 %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement.

Calibrated by:	ART REUST	Reviewed by: them bench
Calibration Tech	nician: atke	2.A. Representative: The

Reviewed Date: C32805 Calibration Date: 3-28-2005 Claulatel activity on 3-14-2018 TOBE - 3,199 dpm = 128 dpm Mutuated

Anelytical Services 7021 Pen American Freeway Ni Albuquerque, New Mexico 87199-4234 (505) 345-3461 Pax (565) 761-5411 Toll Free (866) RAD-LABS (723-5227 www.eberlineservices.com AVM Environmental Services, Inc. HP-210/Scaler Calibration

Scaler HV: <u>900</u> VDC Scaler Threshold (Input Sensitivi Source Counts: <u>961</u> / <u>1</u> Mins @ 1.0 cm	ty): <u>10.0</u> mV <u>1%</u> (1308 Source CPM BKG CPM <u>956</u> <u>48</u> <u>940</u> <u>44</u>
Background Counts: <u>45</u> / <u>1</u> Mins Net CPM: <u>916</u> Eff = Net cpm/source dpm 0.29	972 45 960 39 980 46 Average 961 45
Function Check: Function check source: <u>1% U308 in Con</u> Function Check cpm: <u>3600 cpm</u> Range 2880-4320 cpm Comments	Active Area = 21 cm²
Data: 3-13-18 Calibrated	IN VARA

**AVM Environmental Services Inc.** Scaler/Ratemeter Calibration Form

Model Ludlam 12 S/N 274216

Calibration Source Ludlum Model 500 Pulser 5# 114513

Threshold (input sensitivity)	10	mV	Left or Set at _	10	_mV	
Window, In/Out_N/A	Window	NIA	mV			
Pulser Amplitude Set @	2	0	mV			

ntine Dale

Range/Mode	(Pulser Setting) cpm x multiplier	As Found Reading	Left or Set Reading
X	40×10	400	400
×10	40×100	4000	4000
× 100	40×1K	40,000	40,000
X 1000	40×10K	400,000	400,000

HV Set @ 900 VDC

. Calibrated By Date 8-1-17

Customer AV Date Dete New Instrur T72 °F	Model No. / 3 MENVIRONMENTA 5-Jul-17 ment Instrument R RH4	CERTIFIC/           Serial No.         600           L SERVICES            Cal Due E            eceived         Within 1           49         %         Alt	ATE OF CALIB	B-Jul-18 of Tol. Re Motor	501 Oak Street 325-235-5494 Sweetwater, TX 79554 Cal. Interval quiring Repair Ot Zeroed Mecha	RDER NO. 203 1 Year Procedure her-See Comments inical Check	CERT # 4084.0
	P	ULSE WIDTH			CUSTOMER PO	1A	
	As Found	As Left	Accepta Range (	ble µs) ± 10%			
NEG PULSE	1.7	1.7	1.5 -	1.9			
POS PULSE	1.6	1.6	<2.	25			
	te e henre ar rive		PULSE AMPLIT	UDE			
Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%	Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%
1 V	11	11	0.9 - 1.1	4V	4.2 V	4.2 V	3.6 - 4.4
100 mV	JOO mV	Ino on V	90 - 110	400 mV	420 mV	420 mV	360 - 440
10 mV	10 mV	10 mV	9-11	40 mV	42 m V	42 m V	36 - 44
1 mV	Inv	Inv	0.9 - 1.1	4 mV	4.2 mV	4.2 mV	3.6 - 4.4

	PULSE FREQU	JENCY (PERIOD)		Reference	As Found	As Left Voltage Reading	Acceptable
Pulser	As Found	As Left	Acceptable	Voltage	Voltage Reading		Range ± 5%
nge	Period	Period	Range ± 2%	500 V	500	500	475 - 525
10K	6.674	6.674	6.534 - 6.8	2000 V	1990	1990	1900 - 2100
x 1K	66.74	66.74	65.34 - 68				
x 100	667.4	667.4	653.4 - 680		As Found	As Left	Acceptable
x 10	6674	6674	6534 - 6800	CPM Reading	cpm Reading	cpm Reading	Range ± 10%
x1	66.75	66.75	65.34 - 68	MAX	992	992	981 - 999
x 0.1	90	90	88.2 - 91.8 Counts	MIN	0-1	0-1	0 - 1*

\* READING OF 0-99 IS ACCEPTABLE FOR INSTRUMENTS WITH A S/N 100000 AND BELOW AND MAIN BOARD = 5208-066.

COMMENTS:

Cal'd w/ 39" cable.

Ludium Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. ISO/IE 17025:2005(E) Reference Instruments: Model \_\_\_\_\_\_\_ SIN 18564124506068Cal Date \_\_\_\_\_\_ 2016 Frequency Counter Model Gas- 6103 S/N EP832241 Cal Date 2-1726 2017 Oscilloscope Model Fluke B3 S/N 94000441 Cal Date 3. May 2017 Voltmeter Templey William Tineley 2.2.00 Date 5 July Title Calibrator rator Title Service Dept QC Date SJ QC'd By

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# CERTIFICATE OF CALIBRATION

Electroplated Beta Standard

and the second second				S.O.# 6233 P.O.# 1093
Description of Standard:				
Model No. DNS-14	Serial No.	5442-05	Isotope	SrY-90
Electroplated on polished	Ni	disc,	0.79	mm thick.
Total diameter of 4.7	7 cm a	nd an active d	liameter of	4.45 cm.

The radioactive material is permanently fixed to the disc by heat treatment without any covering over the active surface.

### Measurement Method:

The 2pi beta emission rate was measured using an internal gas flow proportional chamber. Absolute counting of beta particles emitted in the hemisphere above the active surface was verified by counting above, below, and at the operative voltage. The calibration is traceable to NIST by reference to an NIST calibrated beta source  $S/N = \frac{4002-02}{2}$ .

#### Measurement Result:

The observed beta count rate from the surface of the disc per minute (cpm) on the calibration date was:

3,050 + 122

The total disintegration rate (dpm) assuming \_\_\_\_\_\_ & backscatter of beta particles from the surface of the disc, was:

4,370 + 174 (\_\_\_\_\_\_\_ 0.00197 μci)

The uncertainty of the measurement is 4 %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement.

Calibrated by:	ART REUST	Reviewed by: the service
Calibration Tech	nician: atte	2.A. Representative: Tolla =
		00000

Calibration Date: 3-28-2005 Reviewed Date: C32805 Claulatel activity on 3-14-2018 TOBE - 3,199 dpm = 128 dpm Mutual

Analytical Servica 7021 Pan Amarican Freeway N Albuquerque, New Mexico 87109-423 (505) 345-3461 Fax (505) 761-641 Toll Free (866) RAD-LABS (723-5227 www.eberlineservices.com AVM Environmental Services, Inc. HP-210/Scaler Calibration

	Source CPM	BKG CPM
Source Counts: 1033 / 1 Mins (g. 1.0 cm	1105	41
Conference 43 / Mine	1020	48
	1100	
Net CPM: 1012	1000	45
Augrose	1050	112
Function Check:		
Function check source: 1% U308 ore in Can Function Check cpm: 3950 com		
Comments	Active	Area = 21

**AVM Environmental Services Inc.** Scaler/Ratemeter Calibration Form

.5

mV

Model Ludlan 12 SN 274216 Calibration Source Ludlan Model 500 Pulser S# 114513

Threshold (input sensitivity),	Found at	10	mV	Left or Set at _	10
Window, In/Out_N/A	Window	NA	mV		
Pulser Amplitude Set @	2	0	mV		

Range/Mode	(Pulser Setting) cpm x multiplier	As Found Reading	Left or Set Reading
X	40×10	400	400
×10	40×100	4000	4000
× 100	HOXIK	40,000	40,000
X 1000	40× 10K	400,000	400,000
		•	

HV Set @ 900 VDC

A	VID.S_	

	Model No. / S	CERTIFIC	ATE OF CALIB	RATION	501 Oak Street 325-235-5494 Sweetwater, TX 79566	U.8A.	CERT # 4084.0
	S-bd-17	Cel Due E	Data d	Liul-18	Cei. Intervel 1	Year Procedure	M500, Rev. 5
New Instrum     T72_ °F	nent Instrument Re RH4	ULSE WIDTH	Tolerance Out o	of Tol. Rec	uiring Repair Oth Zeroed Mechan CUSTOMER PO	nicel Check	
	As Found	As Left	Accepta Range (	bie us) ± 10%	_		
NEG PULSE	1.7	1.7	1.5 -	1.9			
POS PULSE	1.6	1.6	<2.	25			
			PULSE AMPLIT	JDE			
Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%	Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%
1V	11	11	0.9 - 1.1	4V	4.2 V	4.2 V	3.6 - 4.4
100 mV	JOO m V	100 mV	90-110	400 mV	420 mV	420 mV	360 - 440
10 mV	10 mV	10 mV	9-11	40 mV	42 ~ V	42 m V	36-44
1 mV	Inv	Inv	0.9 - 1.1	4 mV	4.2 mV	4.2 mV	3.8 - 4.4

PULSE FREQUENCY (PERIOD)		Reference	As Found	As Left	Acceptable		
Pulser	As Found	As Left	Acceptable	Voltage	Voltage Reading	Voltage Reading	Range ± 5%
nge	Period	Period	Range ± 2%	500 V	500	500	475 - 525
x 10K	6.674	6.674	6.534 - 6.8	2000 V	1990	1950	1900 - 2100
x 1K	66.74	66.74	65.34 - 68				
x 100	667.4	667.4	653.4 - 680		As Found	As Left	Accestable
x 10	6674	6674	6534 - 6800	CPM Reading	cpm Reading	opm Reading	Range ± 10%
x1	106.75	66.75	65.34 - 68	MAX	992	992	981 - 999
x 0.1	90	90	88.2 - 91.8 Counts	MIN	0-1	0-1	0 - 1*

\* READING OF 0-99 IS ACCEPTABLE FOR INSTRUMENTS WITH A S/N 100000 AND BELOW AND MAIN BOARD = 5208-066. COMMENTS:

Cal'd w/ 39" cable.

Lucium Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. ISO/E 17025:2005(E)

Reference Instruments:			
Frequency Counter	Model S	N 185641245afebas63Cei Date	3-Nov 2016
Oscilloscope	Model 608-6103 8	N EP832241 Cal Date	2-156 2017
Voltmeter	Model Fluke B3 S	N Gei Date	3. 11ay 2017
Grator William Tine	2 2. Diegion Timelen	Title Calibrator	Date 5-Augu 2017
ACT BY RU	- 1/ ha	The Service Den	+00 pm 57.117
		Service Dep	

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AC Inst	essed Disiscinio (	HI-Pol) and Con	inully Test
Only p	alled:		_



# ICATE OF CALIBRATION

Electroplated Beta Standard

Description of Standard:				P.O.# 1093
Model No. DNS-14	_ Serial No	5442-05	Isotope_	SrY-90
Electroplated on polished	Ni	disc,	0.79	mm thick.
Motal diamater of 4.7	7	ad an action	diameter of	4.45 ~~~

The radioactive material is permanently fixed to the disc by heat treatment without any covering over the active surface.

### Measurement Method:

The 2pi beta emission rate was measured using an internal gas flow proportional chamber. Absolute counting of beta particles emitted in the hemisphere above the active surface was verified by counting above, below, and at the operative voltage. The calibration is traceable to NIST by reference to an NIST calibrated beta source  $S/N_{=}4002-02_{=}$ .

#### Measurement Result:

The observed beta count rate from the surface of the disc per minute (cpm) on the calibration date was:

> 3,050 + 122

The total disintegration rate (dpm) assuming \_\_\_\_\_40 \_\_ % backscatter of beta particles from the surface of the disc, was:

<u>4,370</u> + <u>174</u> (<u>0.00197</u> μCi)

The uncertainty of the measurement is \_\_\_\_\_\_ %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement. i n n

Calibrated by: ART REUST Rev	viewed by: the	man
Calibration Technician: atken	2.A. Representat	ive: Mars
Calibration Date: 3-28-2005	Reviewed Date:	032805
Salaulatel activity on 3-14-2018		Analytical Servia 7021 Pas American Freeway
TOBE - 3,199 dpm = 1	28 dpm	Albuquerque, New Mexico 87189-42 (505) 345-3461 Pax (565) 761-54 Tail Free (866) RAD-LARS (722-521

**Analytical Servia** 7021 Pas Americas Freeway Albuquergus, New Mexico 87189-42 (505) 345-3461 Pax (565) 761-54 Tell Free (866) RAD-LABS (723-521 www.sberilaeservices.c

# AVM Environmental Services, Inc Alpha/Beta Counter Calibration

Model: Ludlum 2929/43-10-1, S/N 74084/PR069370 Detector Calibration

Alpha Input Sensitivty:	175
Beta Input Sensitivity:	4
Beta Window:	50

Alpha Source  $\frac{71-230}{5.9-90} \frac{0NS-11}{5#1310}, \frac{9480}{9480} dpm (uns)$ Beta Source  $\frac{5.9-90}{5.9-90} \frac{0NS-14}{5#5442-05}, \frac{3199}{3199} dpm$ HV Readout: Fluke 8020B Multimeter with detector connected

HV	Alpha CPM	Alpha BKG CPM	Beta CPM	Beta BKG CPM
850				
875				
900				
925				
950	3380	1	1221	43
975	3549	1	1249	49
1000	3581	2	1263	51
1025	3579	2	1262	51
1050	3594	3	1281	55
1075	3648	2	1279	59
1100	3702	3	1309	68
1125	3828	4	1366	84
1150				

HV Set @ 100 VDC

Alpha Source:	Th-230	942	80	dom	
Alpha Counts	35955	1	10	Minutes	
BKG Counts	9	1	10	Minutes	

Alpha Eff =	CPM, Net dpm (Source)	=	480	=	0.379
Beta Source	5.4.90	3199 dpm			
<b>Beta Counts</b>	12585	<u> </u>	ites		
BKG Counts	s <u>531</u>	<u>/ 10</u> Minu	ites		
Beta Eff =	CPM, Net	= 12	259	=	0.393
	dpm (Source)	3	199		
Alph Fo	- Range	Th-230 #1310	: 28674.	43146	1 10 min
Bate FC	- Ronge	5. 4.90 # 5442	-05: 100	68-151	02/10 mi
Date: 3-1	3-18	Tech:	2/2/12	~	

# AVM Environmental Services, Inc Alpha/Beta Counter Calibration

Model: Ludium 2929/43-10-1, S/N 74084/PR069370 Scaler Calibration

Scaler Calibration Source: Ludlum 500 Pulser, SR#114513 HV: <u>1000</u> Alpha Input Sensitivty set @: <u>175</u> mV Beta Input Sensitivity set @: <u>4</u> mV Beta Window set @ : <u>50</u> mV

Scaler Calibration

	Pulse input Sensitivity	Pulser Reference Cal Point CPM	Instrument Reading As Found CPM	Instrument Reading Set or Left at CPM
Alpha		40 CPM	40	40
Channel 200 Digital	400 CPM	399	399	
	4K CPM	3993	3993	
Readout		40K CPM	39997	39997
Beta		40 CPM	40	40
Channel 29	25	400 CPM	401	401
	d	4K CPM	4004	4004
Readout	-	40K CPM	40010	40010

Date: 3-13-18

Tech: Tallad



.

# CERTIFICATE OF CALIBRATION

### Electroplated Alpha Standard

		S.O.#
Description of Standard:		P.O.#05173
Model No. DNS-11	Serial No S-1310	IsotopeTh-230
Electroplated on polished	<u>SS</u> disc, 0.79	mm thick.
Total diameter of <u>4.77</u>	cm and an active di	ameter of4,45 cm.
The radioactive material is any covering over the active	permanently fixed to the dis surface.	sc by heat treatment without
Measurement Method:		
The 2pi alpha emission rate chamber. Absolute counting active surface was verified The calibration is traceable b/N	was measured using an interr of alpha particles emitted i by counting above, below, ar to NIST by reference to an	hal gas flow proportional in the hemisphere above the hd at the operative voltage. NIST calibrated alpha source
The observed alpha particles the calibration date was:	emitted from the surface of	the disc per minute (cpm) on
The observed alpha particles the calibration date was: <u>4.810</u>	emitted from the surface of	the disc per minute (cpm) on
The observed alpha particles the calibration date was: <u>4.810</u> The total disintegration rat the surface of the disc, was	e emitted from the surface of <u>+ 144</u> e (dpm) assuming 1.5% backso :	the disc per minute (cpm) on 

The uncertainty of the measurement is 3 %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement.

Calibrated by: <u>ART REUST</u>	Reviewed by: Mala
Calibration Technician:	Rento.A. Manager: Clauter Mctor

Valibration Date:	6-14-2011	Reviewed Date:	6-14-11
1			Source Manufactu

Source Manufacturing Lab 7021 Pan American Freeway NE Albuquerque, New Mexico 87109-4238 (505) 761-5413 Fax (505) 761-5416 areust@eberlineservices.com

. . . .



# CERTIFICATE OF CALIBRATION

	Electrop	lated Beta Stand	lard		
				S.O.# 6233	
Description of Standard:				1095	
Model Nc. DNS-14	Serial No	. 5442-05	Isotope_	SrY-90	
Electroplated on polished	Ni	disc,	0.79		thick.
Total diameter of 4.7	7 0	m and an active	diameter of	4.45	cm.

The radioactive material is permanently fixed to the disc by heat treatment without any covering over the active surface.

#### Measurement Method:

The 2pi beta emission rate was measured using an internal gas flow proportional chamber. Absolute counting of beta particles emitted in the hemisphere above the active surface was verified by counting above, below, and at the operative voltage. The calibration is traceable to NIST by reference to an NIST calibrated beta source S/N = 4002-02.

#### Measurement Result:

The observed beta count rate from the surface of the disc per minute (cpm) on the calibration date was:

3,050 + 122

The total disintegration rate (dpm) assuming <u>40</u> % backscatter of beta particles from the surface of the disc, was:

\_\_\_\_\_4,370 + 174 (\_\_\_\_\_0.00197 μCi)

The uncertainty of the measurement is 4 %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement.

Calibrated by: ART REUST	Reviewed by: the Senter
Calibration Technician: atken	2.A. Representative: Tols c
Calibration Date: 3-28-2005	Reviewed Date: 032805

m 3/14/18 3199 dpm

Analytical Services 7021 Pan American Freeway NE Albuquerque, New Mexico 87109-4238 (505) 345-3481 Fax (505) 761-5416 Toll Free (866) RAD-LABS (723-5227) www.eberlineservices.com

ww.iudiums.com	Model No. /	CERTIFIC	ate of Calib 1 114513	RATION	501 Oak Street 325-235-5494 Sweetwater, TX 7955	6, U.S.A.	CERT # 4084.0
Customer AV	M ENVIRONMENTA	L SERVICES				DRDER NO. 203	314713/451652
Date	5-Jul-17	Caj Due I	Date	5-Jul-18	Cal. Interval	1 Year Procedure	M500. Rev. 5
New Instru T. <u>72</u> *F	ment Instrument R F RH	Acceived 🗹 Within 1 49 % Alt	Tolerance Out	of Tol. Red Meter	uiring Repair 0 Zeroed Mech	ther-See Comments anical Check	
		PULSE WIDTH			CUSTOMER PO	IA	
	As Found	As Left	Accepta Range (	ble µs) ± 10%			
NEG PULSE	1.7	1.7	1.5 -	1.9			
POS PULSE	1.6	1.6	< 2.	25			
			PULSE AMPLIT	UDE			
Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%	Reference Amplitude	As Found Amplitude Reading	As Left Amplitude Reading	Acceptable Range ± 10%
1 V	11	11	0.9 - 1.1	4 V	4.2 V	4.2 V	3.6 - 4.4
100 mV	100 m V	100 mV	90 - 110	400 mV	420 mV	420 mV	360 - 440
10 mV	10 mV	IOnV	9 - 11	40 mV	42 mV	42 m V	36 - 44
1 mV	Inv	Inv	0.9 - 1.1	4 mV	4.2 mV	4.3 mV	3.6 - 4.4
	PULSE FRE	QUENCY (PERIOD)		Reference	As Found	As Left	Acceptable

	TOLOLITALE	Eliot (i Eliob)		Interence	All I Valid	Ma, Lon	1000000000
Pulser	As Found	As Left	Acceptable	Voitage	Voltage Reading	Voitage Reading	Range ± 5%
Pange	Period	Period	Range ± 2%	500 V	500	500	475 - 525
× 10K	6.674	6.674	6.534 - 6.8	2000 V	1990	1950	1900 - 2100
x 1K	66.74	66.24	65.34 - 68				
x 100	667.4	667.4	653.4 - 680		As Found	As Left	Acceptable
x 10	6674	6674	6534 - 6800	CPM Reading	cpm Reading	cpm Reading	Range ± 10%
x1	66.75	66.75	65.34 - 68	MAX	992	992	981 - 999
x 0.1	90	90	88.2 - 91.8 Counts	MIN	0-1	0-1	0 - 1*

\* READING OF 0-99 IS ACCEPTABLE FOR INSTRUMENTS WITH A S/N 100000 AND BELOW AND MAIN BOARD = 5208-066.

COMMENTS:

Cal'd w/ 39" cable.

Ludium Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. ISO/IE 17025:2005(E)

Model S/N	185641245a6a6a63Cal Date _3-Nov	2016
Model 609-6103 S/N	EP832241 Cal Date	2017
Model Fluke B3 S/N	94000441 Cal Date 3 . 2014	1 2017
2) iolian Temaleu	Title Calibrator	Date 5- July 2017
al la .	Title Service Dept OC	Date SJUID
	Model <u>1856</u> SIM Model <u>GOS-6103</u> SIM Model <u>Fluke B3</u> SIM 2): <u>becom Temaley</u>	Model S/N /85/41/24/50/00063 Cal Date _3-Nov Model <u>Gas-6103</u> S/N <u>EP832241</u> Cal Date <u>2-jee</u> Model <u>Fluke B3</u> S/N <u>94000441</u> Cal Date <u>3.7000</u> <u>2): Decime Temaley</u> Title <u>Calibrator</u> <u>3.1000</u> Title <u>Service Dept QC</u>

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AC Inst. Par	sed Dielectric (HI-Pot) and Continuity Test
Only Faile	ed:

### AVM Environmental Services, Inc. Scaler/Ratemeter - 2" x 2" Nal Detector Function Check

Function Check Source ID: 1% U<sub>3</sub>O<sub>8</sub> Ore in Sealed can

SPA-3

2" x 2" Nal Detector ID: #30

Acceptable background Count (cpm) Range (209	6300	to	9450	(Bare)
Acceptable background Count (cpm) Range (209	) 2334	to	3502	(collimated)
Acceptable Source Count (cpm) Range (20%)	77097 0		115645	-

Date	Scaler/Ratemeter	Physical Check	Cal Due	Battery <sup>(1)</sup> Volts or OK	HV Volts	THR mV <sup>(2)</sup>	Window In or OUT <sup>(3)</sup>	C.C. <sup>(4)</sup>	BKG Counts	Source Counrts	Within Acceptable Range Y or N	MDC pCi/gm	Tech
3-16-18	68782	/	8-1-18	/	900	10.0	out	1	7894 (A) 2880 (C)	96 244	y	41.5	VP
3-20 18	68782	~	8-1-18	V	900	100	out	1	7998(B)	96324	.4	4.5	m
3-21-18	\$262315	1	8-1-18	V	900	10.0	out	1	8015	96101	y	41.5	40
3-22-18	12221 #262315	V	8-1-18	V	900	10.0	art	1	7938	94485	Y	11.5	no
3-23-18	12221 # 262325	V	8-1-18	V	981	10.0	out	1	7998	96228	Y	21.5	-yp
3-26-18	12221	V	8-1-18	V	900	10.0	out	1	8020	96195	X	L1.5	m
3-27-18	12221	V	8-1-18	V	900	100	out	1	7899	96334	Y	L1.5	40
3-28-18	#2+2325	~	8-1-18	V	901	10.0	out	1	7966	96228	Y	K1.5	ho
3-29-18	12221 #262325	~	8-1-18	V	900	10.0	out	l	7849	96199	Y	415	ino
3-30-18	12231 # 262325	~	8-1-18	V	901	10.0	out	1	8005	96419	Y	K1.5	200
4-4-18	1220801	~	8-1-18	V	900	10-0	out	1	7928	96109	Y	K1.5	np
5-6-18	12221 #2908-1	V	8-1+18	~	900	23	out	1	7155	97815	4	6.1.5	UP
						-							

Note: (1) Battery Voltage for Ludium 2221 must be >5.3 volts; (2) Threshhold must be at 10.0 mV; (3) Window Position must be OUT; (4) CC on L2241-2 set at 0.001 For L2241-2 Check HV and Threshold using Ludium 500 pulser.

### AVM Environmental Services, Inc. Scaler/Ratemeter - 2" x 2" Nai Detector Function Check

Function Check Source ID: 1% U<sub>3</sub>O<sub>8</sub> Ore in Sealed can

2" x 2" Nal Detector ID: #33

6204 9307 Acceptable background Count (cpm) Range (20%) (Bare) 2365 3547 Acceptable background Count (cpm) Range (20%) to (collimated) 115280 76854 Acceptable Source Count (cpm) Range (20%) to

Data	Seeler/Retemptor	Physical	Cal Due	Battery <sup>(1)</sup>	HV	THR	Window	C C <sup>(4)</sup>	BKG Counts	Source Counts	Within Acceptable Range	MDC	Tech	
3-11-18	L2221	CHECK	8-1-18	VOIDOICK	900	10.0	mul	1	7618 B	95018	Y	21.5	V	
3.19.18	42221	1	87.18	/	900	100	out	1	160136	95281	7	41.5	VP	BK1 16-17.
3-20-18	12221	V	8-1-18	V	900	100	out	1	8015	95196	Y	41.5	20	
3-21-18	L2221 52# 78782	V	8-1-18	~	900	10.0	out	1	8098	95319	Ŷ	41.5	20	
3-22-18	122221	/	8-1-18	V	900	10.0	out	1	7910	95294	Y	21.5	20	
3-23-18	22221	/	8-1-18	~	900	10.0	out	1	8029	95002	Y	41.5	w	
3-26-18	22221	V	8-1-18	V	900	10.0	out	1	79:47	95248	Y	415	np	
3-27-18	42221	V	8-1-18	V	900	10.0	out	1	7904	95411	Y	41.5	20	
3.28-18	416782	~	8-1-18	V	900	10.0	out	1	8018	95224	Y	21.5	20	
3-29-18	418782	~	8-1-18	V	900	10.0	out	1	7877	95224	Y	21.5	ng	
3-30-18	+2221	~	8-1-18	V	900	100	out	1	8076	95322	Y	41.5	- up	
34-4-18	12221	~	8-1-18	V	900	10.0	out	1	8004	95232	Y	41.5	sp	
4-6-18	268782	~	8-1-18	V	901	10.0	out	1	7906	95066	Y	<1.5	w	1
4-11-15	12221 +68782	V	8-1-18		900	10.0	out	1	8003	95198	Y	21.5	np	
4-16-18	12221 + 68782	1	8-1+18	~	901	100	out	1	8/18	95396	Y	21.5	40	
4-17-18	22224	/	8-1-18	V.	900	10-0	out	l	8009	95618	Y	4.5	ip	
4-18-18	468782	~	8-1-18	~	900	10.0	at	1	7916	95011	Y	21.5	ho	
4-19-18	+68782	V	8-1-18	V	900	100	out	1	8117	96199	Y	K1.5	hy	

Note: (1) Battery Voltage for Ludium 2221 must be >5.3 volts; (2) Threshhold must be at 10.0 mV; (3) Window Position must be OUT; (4) CC on L2241-2 set at 0.001 For L2241-2 Check HV and Threshold using Ludium 500 pulser.

### AVM Environmental Services, Inc. Scaler/Ratemeter - 2" x 2" Nal Detector Function Check

Function Check S 2" x 2" Nal Detect	Source ID: 1% U <sub>3</sub> O <sub>8</sub> O tor ID:	re in Sealed	can -3			Acceptable background Count (cpm) Range (20%) 2365 to 3547 Acceptable Source Count (cpm) Range (20%) 76854 to 115280 Within							
Date	Scaler/Ratemeter	Physical Check	Cal Due	Battery <sup>(1)</sup> Volts or OK	HV Volts	THR mV <sup>(2)</sup>	Window In or OUT <sup>(3)</sup>	C.C. <sup>(4)</sup>	BKG Counts cpm	Source Counrts cpm	Acceptable Range Y or N	MDC pCi/gm	Tech
5-7-18	L2221 290	1	8-1-18	5.7	900	10	out	-	8178 Bare	98532	7	4.2	UP
5-9-18	L2241/287	V	8-1-18	OK	900	10	-	-	8090	97400	Y	21.2	NP
572-18	12221/#33	V	8-1-18	OK	900	16	art	~	8124	97428	Y	21-2	up
										<b>⊢</b>			

Note: (1) Battery Voltage for Ludium 2221 must be >5.3 volts; (2) Threshhold must be at 10.0 mV; (3) Window Position must be OUT; (4) CC on L2241-2 set at 0.001 For L2241-2 Check HV and Threshold using Ludium 500 pulser.

## AVM Environmental Services, Inc. Micro R Meter Function Check Form

Micro R Meter: Ludlum 19, SR#76248

Function Check Source ID: 1% U<sub>3</sub>O<sub>8</sub> Ore in Sealed can

Function Check @ Calibration \_\_\_\_\_

Acceptable Function Check Reading (uR/hr) Range (20%)

to

132

88

Dete	Dhusiaal Chask	Col Data	Battery <sup>(1)</sup> Volts	BKG Reading	Source Reading <sup>(2)</sup>	Within Acceptable Range	Cal Dura	Tech
	Physical Check	Cal Date	OFOR	uR/nr	uR/nr	YORN	Cal Due	Tech
5-16-10	V	7-5-17	~	10-12	110	У	7-5-18	VP
3-19-18	V	7-5-17	V	9-11	110	Y	7-5-18	2
3-20-18	V	7-5-17	~	10-12	110	Y	7-5-18	ap
3-21-18	V	7=5-18	~	10-13	110	Y	7-5-18	no
3-22-18	V	7-5-18		10-12	109	4	7-5-18	no
3-23-18	~	7=5-18	~	10-11	109	Y	7-5-18	ap
3-26-18	V	7-5-18	V	10-12	110	Y	7-5-18	240
3-27-18	/	7-5-18	V	10-11	109	4	7-5-18	sp
3-28-18	V	7-5-18	V	10-12	110	Y	7-5-18	n
3-29-18	V	7/5/18	V	9-11	109	Y	7-5-18	20
3-30-18	V	7-5-18	/	10-12	110	Y	7-5-18	wo
4-4-18	V	7-5-18	V	9-12	109	Y	7-5-18	no
4-6-18	V	7-5-18	V	10-12	110	Y	7-5-18	20
4-11-18	$\checkmark$	7-5-18		10-12	109	Y	7-5-18	NO
4-16-18		7-5-18	1	10-11	108	4	7-5-18	ing .
4-13-18		7-5-18		10-12	110	Y	7-5-18	20
4-18-18	~	7-5-18	V	9-12	110	Y	7-5-18	af l
4-19-18	V	7:5-18	~	10-11	109	Y	7-5-18	20

Note: (1) Battery Voltage must be within BAT TEST Range (2) Function Check Source must be placed in the circle on the front side of the meter

### AVM Environmental Services, Inc. Micro R Meter Function Check Form

Micro R Meter: Ludlum 19, SR#76248

Function Check Source ID: 1% U<sub>3</sub>O<sub>8</sub> Ore in Sealed can

Function Check @ Calibration \_\_\_\_\_\_\_

Acceptable Function Check Reading (uR/hr) Range (20%)

40	
10	

92

38

Date	Physical Check	Cal Date	Battery <sup>(1)</sup> Volts or OK	BKG Reading uR/hr	Source Reading <sup>(2)</sup> uR/hr	Within Acceptable Range Y or N	Cal Due	Tech
3-16-18		7-5-17	$\checkmark$	10-12	115	y	7-5-18	VP
4-30-18	V	7-5-17		9-12	112	Y	7-5-18	an
5-1-18		7.5.17		10-12	110	Y	7-5-18	np
5.2-18		7-5-17	~	10-11	115	Y	7-5-18	no
53-18		7-5-17		10 12	110	Y	7-5-18	ino
5-7-18	V	7-5-17		9-10	)15	7	7-5-01	UP
5-9-18	~	7-5-17		10-11	110	У	7-5-18	20
5-12-1 18	/	7-5-17	1	10-11	110	Y	7-5-18	rp

Note: (1) Battery Voltage must be within BAT TEST Range (2) Function Check Source must be placed in the circle on the front side of the meter

### AVM Environmental Services, Inc. Ludium SCA L2221 - 44-20 3x3 Nal Detector Function Check 559 - 659 KeV Gamma Radiation Soil Screening

L2221 #68782

Function Check Source ID: 1% U<sub>3</sub>O<sub>8</sub> Ore in Sealed can

Acceptable background Count (cpm) Range (20%)

Ludium 44-20 3x3 Nal Detector, #PR295573

57 10 85 12926 10 19388 Acceptable Source Count (cpm) Range (20%)

Date	Physical Check	Cal Date	Battery <sup>(1)</sup> Volts or OK	HV Volts	Threshhold mV (2)	Window mV	Window In/Out	BKG Counts cpm	Source Counrts cpm	Within Acceptable Range Y or N	MDC pCi/gm	Tech
4-16-18	V	4-14-19	1	590	559	100	in	73	15876	1	~	JP
4-17-18	/	4-14-19	V	590	559	100	· in	78	16218	٢	8	VP
4-18-18	V	4-14-19	1.	590	559	100	in	81	16070	4	-	UP
4-19-18	$\checkmark$	4-14-19	V	590	559	100	in	72	16114	>	-	UP
				-								
							1			-		

Note: (1) Battery Voltage for Ludium 2221 must be >5.3 volts; (2) Threshhold must be at 220 mV; (3) Window @ 440, must be IN

### **AVM Environmental Services, Inc** Scaler/Ratemeter - HP-210L Detector Function Check

Scaler/Ratemeter:

L12 S# 274126

Function Check Source ID: 1% U<sub>3</sub>O<sub>8</sub> Ore in Sealed can

HP-210 Detector:

ANA-1

Acceptable background Count (cpm) Range (20%) 2880 Acceptable Source Count (cpm) Range (20%)

40 to 4320 to

60

Date	Physical Check	Cal date	Battery Volts or OK	HV Volts	BKG Counts cpm	Source Counrts cpm	Within Acceptable Range Y or N	Comments	Tech
3-16-18	~	3-13-18		900	48	3600	7		VP
3-19-18	V	3-13-18	~	900	51	3600	Y		NO
3-20-18	~	3-13-18	~	900	49	3600	Y		20
3-21-18	V	3-13-18	~	900	53	3600	V		20
3-22-18	V	3-13-18		900	51	3600	1		no
3-23-18	~	3-13-18		900	47	3600	V	•	rp
3-26-18	/	3-13-18	V	900	55	3600	Ý		np
4-6-18	V	3-13-18	~	900	49	3600	4		1p
4-19-18	~	3-13-18		900	50	3600	7		ng.
4-30-18	~	3-13-18	~	900	50	3500	Y		ap
5-1-18	V	3-13-18	V	900	42	3600	Y		20
5-2-18	V	3-13-18	~	900	52	3600	Y		no
5-318	V,	3-13-18	V	900	49	3600	1		20
5-7-18	$\checkmark$	3-13-18	1	900	48	3600	Y		mo
5-9-18	1	3-13-18	V	900	51	3600	ý		np
5-12-18	/	3-13-18		900	42	3600	4		re.
150							(		

Note: (1) Threshhold must be at 100 mV; (2( C.C. for Eberline ESP scaler must be 1.0+00

### **AVM Environmental Services, Inc** Scaler/Ratemeter - HP-210L Detector Function Check

Scaler/Ratemeter: <u>LZZ41-Z(#287029)</u> HP-210 Detector: <u>ANA-Z</u>

Function Check Source ID: 1% U<sub>3</sub>O<sub>8</sub> Ore in Sealed can

Acceptable background Count (cpm) Range (20%) Acceptable Source Count (cpm) Range (20%)

35 160 to

3

Date	Physical Check	Cal date	Battery Volts or OK	HV Volts	BKG Counts	Source Counts cpm	Within Acceptable Range Y or N	Comments	Tech
3-26-18	V	313/18	OK	900	48	3800	V		MP
3-27-18	/	3/13/18	OK	900	52	3850	Y		no
3-28-18	V	3/13/18	OK	900	56	3856	Y		nop
3-29-18	V	3-13/18	OK	900	49	3800	Y		N
3-30-18	V	3/13/18	OK	900	51	3800	4		w
4-4-18	V	3-13-18	oK	900	49	3800	Y		200
4-16-18	V	3-13-18	OK	900	50	3800	Y		20
4-17-18	V	3-13-18	OK	980	60	3800	Y		erp
4-18-18	V	3-13-18	OK	900	54	3500	Ý		30
							,		
	[								

Note: (1) Threshhold must be at 100 mV; (2( C.C. for Eberline ESP scaler must be 1.0+00

### **AVM Environmental Services, Inc** Ludlum 2929 Scaler/43-10-1 Alpha-Beta Counting System Function Check Form

L2929 SR#74084/43-10-1 SR#PR069370

 Function Check Source ID::
 7/1 - 230 DNS-11 (# 1310) 9480 dpm

 Acceptable background Count (cp10m) Range (20%)
 0
 to
 11

 Acceptable Source Count (cp10m) Range (20%)
 28764
 to
 43146

Date	Physical Check	Cal date	HV Volts	Alpha BKG Counts (CP10M)	Alpha Source Counts (CP10M)	Beta BKG Counts (CP10M)	Beta Source Counts (CP10M)	Within Acceptable Range Y or N	Comments	Tech
3-13-18		3-13-18	1000	3	35955	-	-	Y		np
3-29-18	V	3-13-18	1000	2.	35435	-	-	Y		np
4-2-18	/	3-13-18	1000	1	36176	-	-	Y		4
4-7-18	1	3-13-18	1000	1	36478	_	-	Y		MP
4-19-18	~	3-13-18	1000	2	35228	-	-	Y		as
4-23-18		3-13-18	1000	3	36101	-	-	4		40
									-	
	1									

Note: (1) Calibration HV set @1000 V