

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-701, Final Status Survey Plan Development		
		Revision: 10	Appendix P-4, Page 1 of 1

APPENDIX P-4

FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area:	LSA 08	Description:	Tc-99 SEA Open Land Area
Survey Unit:	10	Description:	Central Open Land Area in "Area 6"
Survey Type:	FSS	Classification:	Class 1

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L08-10-01-T-S-S-00	Uniform	S	435	434.5	864491.0	827118.0	Surface 6-inch grab
L08-10-02-T-R-S-00	Uniform	S	434.51	430.1	864491.0	827118.0	Root 4.4-ft composite
L08-10-04-T-S-S-00	Uniform	S	435.5	435.0	864491.0	827160.0	Surface 6-inch grab
L08-10-05-T-R-S-00	Uniform	S	435.01	430.6	864491.0	827160.0	Root 4.4-ft composite
L08-10-07-T-S-S-00	Uniform	S	433.6	433.1	864491.0	827202.0	Surface 6-inch grab
L08-10-08-T-R-S-00	Uniform	S	433.11	428.7	864491.0	827202.0	Root 4.4-ft composite
L08-10-10-T-S-S-00	Uniform	S	435.5	435.0	864455.0	827139.0	Surface 6-inch grab
L08-10-11-T-R-S-00	Uniform	S	435.01	430.6	864455.0	827139.0	Root 4.4-ft composite
L08-10-12-T-E-S-00	Uniform	S	430.58	430.1	864455.0	827139.0	Excavation 6-inch grab
L08-10-13-T-S-S-00	Uniform	S	432.3	431.8	864455.0	827181.0	Surface 6-inch grab
L08-10-14-T-R-S-00	Uniform	S	431.8	427.4	864455.0	827181.0	Root 4.4-ft composite
L08-10-16-T-S-S-00	Uniform	S	436.2	435.7	864418.0	827118.0	Surface 6-inch grab
L08-10-17-T-R-S-00	Uniform	S	435.7	431.3	864418.0	827118.0	Root 4.4-ft composite
L08-10-18-T-E-S-00	Uniform	S	431.3	430.8	864418.0	827118.0	Excavation 6-inch grab
L08-10-19-T-S-S-00	Uniform	S	432.5	432.0	864418.0	827160.0	Surface 6-inch grab
L08-10-20-T-R-S-00	Uniform	S	432.0	427.6	864418.0	827160.0	Root 4.4-ft composite
L08-10-22-T-S-S-00	Uniform	S	432.8	432.3	864382.0	827139.0	Surface 6-inch grab
L08-10-23-T-R-S-00	Uniform	S	432.3	427.9	864382.0	827139.0	Root 4.4-ft composite
L08-10-05-T-R-Q-00	Uniform	Q	435.0	430.6	864491.0	827160.0	Root 4.4-ft composite
L08-10-16-T-S-Q-00	Uniform	Q	436.2	435.7	864418.0	827118.0	Surface 6-inch grab
L08-10-25-P-S-B-00	Uniform	B	433.6	433.1	864501.1	827195.9	Biased 6-inch grab

Green shaded samples are the samples at each sample location, for use in WRS test.

*Elevations are in feet above mean sea level.

** Missouri - East State Plane Coordinates [North American Datum (NAD) 1983]

Surface: Floor = F; Wall = W; Ceiling = C; Roof = R

CSM: Three-Layer (Surface-Root-Excavation) or Uniform DCGLs used

Type: Systematic = S, Biased = B; QC = Q; Investigation = I

Quality Record

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Steps 8.3 Preliminary Data Review and 8.4 Calculation of the Sum-of-Fractions (SOF)

Evaluate Final Status Survey Data: LSA-08-10

TestAmerica Analytical Results Step 8.3.2																																						
Sample ID	Sample Depth (ft)	Type (D=Direct, B=Back, C=C)	Ra-226						Th-232						Th-232						Inferred U-234						U-235						U-238					
			Result	Uncertainty	MDC	Qualifier	Net Result**	Standard Deviation	Result	Uncertainty	MDC	Qualifier	Net Result**	Standard Deviation	Result	Uncertainty	MDC	Qualifier	Net Result**	Standard Deviation	Result	Uncertainty	MDC	Qualifier	Net Result**	Standard Deviation	Result	Uncertainty	MDC	Qualifier								
			Result	Uncertainty	MDC	Qualifier	Net Result**	Standard Deviation	Result	Uncertainty	MDC	Qualifier	Net Result**	Standard Deviation	Result	Uncertainty	MDC	Qualifier	Net Result**	Standard Deviation	Result	Uncertainty	MDC	Qualifier	Net Result**	Standard Deviation	Result	Uncertainty	MDC	Qualifier								
L08-10-01-T-S-S-00	0.00	S	0.789	0.124	0.093	N/A	-0.281	0.000	0.174	0.022	0.218	U	0.643	0.134	0.108	N/A	-0.397	0.000	1.090	N/A	N/A	N/A	-0.120	0.168	0.95	U	1.060	0.490	0.745	N/A								
L08-10-02-T-R-S-00	0.50	S	0.925	0.148	0.071	N/A	-0.145	0.000	0.354	0.054	0.106	0.220	N/A	0.781	0.161	0.095	N/A	-0.219	0.000	0.763	N/A	N/A	N/A	-0.194	0.120	0.807	U	0.793	0.314	0.852	U							
L08-10-04-T-S-S-00	0.00	S	0.884	0.125	0.053	N/A	-0.186	0.000	1.820	1.820	0.222	0.215	N/A	0.880	0.130	0.070	N/A	-0.140	0.000	1.450	N/A	N/A	N/A	-0.109	0.114	0.474	U	1.400	0.436	0.617	N/A							
L08-10-06-T-R-S-00	0.50	S	1.160	0.165	0.068	N/A	0.090	0.000	7.410	7.410	0.685	0.204	N/A	0.886	0.177	0.077	N/A	-0.034	0.000	4.687	N/A	N/A	N/A	-0.369	0.173	0.209	N/A	1.520	0.632	0.911	N/A							
L08-10-07-T-S-S-00	0.00	S	1.500	0.176	0.065	N/A	0.230	0.230	2.360	2.360	0.352	0.238	N/A	1.050	0.177	0.140	N/A	0.050	0.050	3.982	N/A	N/A	N/A	-0.217	0.147	0.573	U	1.420	0.568	0.846	N/A							
L08-10-08-T-R-S-00	0.50	S	1.270	0.182	0.081	N/A	0.200	0.200	0.574	0.574	0.237	0.240	N/A	1.160	0.175	0.128	N/A	0.160	0.160	1.245	N/A	N/A	N/A	-0.067	0.171	0.422	U	0.505	0.226	1.370	U							
L08-10-10-T-S-S-00	0.00	S	0.721	0.116	0.062	N/A	-0.340	0.000	1.770	1.770	0.168	0.251	N/A	0.729	0.147	0.131	N/A	-0.251	0.000	3.820	N/A	N/A	N/A	-0.229	0.154	0.188	N/A	1.280	0.470	0.684	N/A							
L08-10-11-T-R-S-00	0.50	S	1.100	0.147	0.060	N/A	0.030	0.030	19.200	19.200	1.970	0.234	N/A	1.100	0.159	0.128	N/A	0.100	0.100	3.429	N/A	N/A	N/A	-0.182	0.145	0.205	U	1.810	0.607	0.883	N/A							
L08-10-12-T-S-S-00	4.92	S	0.980	0.129	0.059	N/A	-0.144	0.000	0.510	0.510	0.332	0.241	N/A	0.903	0.183	0.113	N/A	-0.097	0.000	4.681	N/A	N/A	N/A	-0.256	0.127	0.173	N/A	1.520	0.515	0.744	N/A							
L08-10-13-T-S-S-00	0.00	S	0.880	0.141	0.068	N/A	-0.184	0.000	24.400	24.400	2.540	0.225	N/A	0.714	0.169	0.105	N/A	-0.089	0.000	15.950	N/A	N/A	N/A	-0.080	0.255	0.243	N/A	3.370	0.860	0.622	N/A							
L08-10-14-T-R-S-00	0.50	S	1.310	0.184	0.084	N/A	0.240	0.240	7.750	7.750	0.246	0.230	N/A	1.110	0.209	0.077	N/A	0.110	0.110	1.330	N/A	N/A	N/A	-0.139	0.382	0.669	U	1.330	0.387	0.961	N/A							
L08-10-15-T-S-S-00	0.00	S	0.532	0.109	0.120	N/A	-0.538	0.000	1.870	1.870	1.183	0.215	N/A	0.730	0.141	0.084	N/A	-0.270	0.000	0.445	N/A	N/A	N/A	-0.077	0.093	0.411	U	0.817	0.436	0.672	N/A							
L08-10-17-T-R-S-00	0.50	S	1.160	0.172	0.069	N/A	0.090	0.090	14.600	14.600	1.750	0.234	N/A	0.949	0.160	0.132	N/A	-0.051	0.000	8.914	N/A	N/A	N/A	-0.461	0.162	0.229	N/A	2.240	0.640	0.879	N/A							
L08-10-18-T-S-S-00	4.92	S	1.090	0.152	0.069	N/A	0.020	0.020	0.659	0.659	0.068	0.230	N/A	1.270	0.198	0.136	N/A	0.270	0.270	1.663	N/A	N/A	N/A	-0.079	0.327	0.543	U	1.860	0.699	0.820	N/A							
L08-10-19-T-S-S-00	0.00	S	0.778	0.111	0.053	N/A	-0.292	0.000	2.010	2.010	0.200	0.226	N/A	0.541	0.089	0.076	N/A	-0.459	0.000	0.980	N/A	N/A	N/A	-0.064	0.085	0.351	U	0.560	0.325	0.959	N/A							
L08-10-20-T-R-S-00	0.50	S	1.140	0.160	0.058	N/A	0.070	0.070	0.031	0.031	0.061	0.236	U	0.952	0.161	0.121	N/A	-0.048	0.000	0.756	N/A	N/A	N/A	-0.038	0.216	0.362	U	0.635	0.285	0.746	U							
L08-10-21-T-S-S-00	0.00	S	0.589	0.099	0.046	N/A	-0.481	0.000	0.670	0.670	0.877	0.421	N/A	0.414	0.090	0.087	N/A	-0.589	0.000	1.154	N/A	N/A	N/A	-0.063	0.120	0.309	U	0.380	0.171	0.719	U							
L08-10-23-T-R-S-00	0.50	S	1.280	0.175	0.079	N/A	0.190	0.190	0.071	0.071	0.082	0.244	U	1.280	0.211	0.190	N/A	0.280	0.280	1.400	N/A	N/A	N/A	-0.077	0.667	0.591	U	1.400	0.630	0.965	N/A							
L08-10-05-T-R-Q-00	0.50	Q	0.993	0.163	0.086	N/A	-0.077	0.000	4.110	4.110	0.468	0.238	N/A	0.648	0.238	0.219	N/A	-0.352	0.000	1.240	N/A	N/A	N/A	-0.114	0.149	0.640	U	1.240	0.361	0.975	N/A							
L08-10-16-T-S-Q-00	0.00	Q	0.800	0.124	0.060	N/A	-0.270	0.000	3.860	3.860	0.459	0.220	N/A	0.718	0.130	0.077	N/A	-0.262	0.000	4.180	N/A	N/A	N/A	-0.221	0.128	0.164	N/A	0.969	0.474	0.725	N/A							
L08-10-25-P-S-E-00	0.00	B	0.527	0.081	0.050	N/A	-0.543	0.000	1.430	1.430	0.187	0.201	N/A	0.624	0.105	0.084	N/A	-0.376	0.000	3.968	N/A	N/A	N/A	-0.219	0.097	0.123	N/A	0.627	0.230	0.565	N/A							
Systematic Minimum			0.000						0.031						0.000						0.445						-0.199		0.390									
Systematic Maximum			0.240						24.400						1.980						35.660						3.370											
Systematic Mean			0.064						4.637						0.054						3.483						0.137		1.332									
Systematic Median			0.070						1.795						0.090						4.090						0.085		1.305									
Systematic Standard Deviation			0.089						7.225						0.094						4.638						0.295		0.719									
Step 8.3.3			With ingrowth, use Ra226 bkg = 1.07										Th232 bkg = 1.0																									
Step 8.4.2			NOTES:																																			
			Gross results in units of pCi/g																																			
			* Background with ingrowth (1.07 pCi/g) subtracted from gross result.																																			
			**Background (1.0 pCi/g) subtracted from gross result.																																			
			U Qualifier: Result is less than the sample detection limit.																																			
			All uncertainty values are reported at the 2-sigma confidence level.																																			

Ave Conc: Ra-226, SS	Ave Conc: Th-232, SS	Ave Conc: Th-232, SS	Ave Conc: U-234, SS	Ave Conc: U-235, SS	Ave Conc: U-238, SS
0.000	0.174	0.000	1.060	-0.120	1.060
-	-	-	-	-	-
0.000	1.820	0.000	1.400	-0.109	1.400
-	-	-	-	-	-
0.230	2.390	0.050	3.982	0.217	1.420
-	-	-	-	-	-
0.000	1.770	0.000	3.828	0.209	1.280
-	-	-	-	-	-
0.000	0.000	0.000	0.000	0.000	0.000
-	-	-	-	-	-
0.000	1.870	0.000	0.445	0.017	0.887
-	-	-	-	-	-
0.000	2.010	0.000	0.580	-0.084	0.580
-	-	-	-	-	-
0.000	0.670	0.000	1.154	0.063	0.390
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
0.029	1.338	0.006	1.556	0.024	0.877
Ave Conc: Ra-226, RS	Ave Conc: Th-232, RS	Ave Conc: Th-232, RS	Ave Conc: U-234, RS	Ave Conc: U-235, RS	Ave Conc: U-238, RS
0.000	0.354	0.000	0.763	-0.134	0.763
-	-	-	-	-	-
0.090	7.410	0.000	6.687	0.369	1.520
-	-	-	-	-	-
0.200	0.574	0.160	1.245	0.067	0.505
-	-	-	-	-	-
0.030	19.200	0.100	3.429	0.182	1.810
-	-	-	-	-	-
0.240	1.750	0.110	1.330	-0.139	1.330
-	-	-	-	-	-
0.090	14.800	0.000	8.914	0.491	2.240
-	-	-	-	-	-
-	-	-	-	-	-
0.070	0.031	0.000	0.756	0.038	0.635
-	-	-	-	-	-
0.190	0.071	0.280	1.400	-0.017	1.400
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
0.114	5.524	0.081	3.066	0.107	1.275
Ave Conc: Ra-226, ES	Ave Conc: Th-232, ES	Ave Conc: Th-232, ES	Ave Conc: U-234, ES	Ave Conc: U-235, ES	Ave Conc: U-238, ES
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
0	3.51	0	4.6812	0.256	1.52
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
0.02	0.659	0.27	1.6626	0.0789	1.86
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
0.010	2.085	0.135	3.172	0.167	1.690

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Steps 8.3 Preliminary Data Review and 8.4 Calculation of the Sum-of-Fractions (SOF)

Root Stratum SOF Verification (unexcavated/not backfilled only) Step 8.4.4a.1					
Depth (ft)	SOF Step 8.4.3	Is Material in Root Stratum?	Is SOF in Root Stratum?	Root count	Excavation count
0.7	0.02	SURFACE	good	1	1
0.7	0.02	ROOT	good	1	1
0.7	0.09	SURFACE	good	1	1
0.7	0.39	ROOT	good	1	1
2.4	0.27	SURFACE	good	1	1
2.1	0.22	ROOT	good	1	1
2.5	0.19	SURFACE	good	1	1
1.8	0.86	ROOT	FLAG	1	1
2.8	0.18	EXCAVATION	good	1	1
4.8	1.11	SURFACE	good	1	1
0.7	0.28	ROOT	good	1	1
0.3	0.08	SURFACE	good	1	1
3.3	0.71	ROOT	FLAG	1	1
0.7	0.18	EXCAVATION	good	1	1
0.7	0.08	SURFACE	good	1	1
1.0	0.05	ROOT	good	1	1
2.8	0.04	SURFACE	good	1	1
0.7	0.26	ROOT	good	1	1
0.7	0.18	good			
3.5	0.18	good			
4.0	0.09	good			
1.9	0.02				
1.86					
0.22					
1.18					
0.24					
Average L (%)		count tot			
		18 8 2 8			

Use corrected net results for all DE calcs 721 Sec. 8.4.2

Step 8.4.1 DCLG₉₀ Measure To-99 All SEAs

Uniform
U-234 195.4
U-235 51.6
U-238 168.8
To-99 25.1
Th-232 2.0
Ra-226 1.9

Step 8.4.5b

Weighted SOF_{net} 0.92

SS	RS	ES
0.444444444	0.444444444	0.111111111

Step 8.4.5c SOF_{net} Re-use Backfill Material 0

Step 8.4.5e SOF_{net} Groundwater 0.08

Step 8.4.5g (C=1) SOF_{net} 0.93 PASS

Step 8.4.6 Calculate the dose contribution for the SU by multiplying SOF_{net} (including contribution from Re-use backfill and Groundwater) by 25 mrem.

9.6 mrem

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Steps 8.3 Preliminary Data Review and 8.4 Calculation of the Sum-of-Fractions (SOF)

Infer U-234 Step 8.3.4			
U-238/U-235	U-234/U-235	U-234	%
0.0	0.0	1.1	0.7
0.0	0.0	0.8	0.7
0.0	0.0	1.4	0.7
4.1	18.1	6.7	3.7
6.5	18.3	4.0	2.4
7.5	18.5	1.2	2.1
6.1	18.3	3.8	2.5
9.5	18.8	3.4	1.6
5.9	18.3	4.7	2.6
3.1	18.1	19.8	4.8
0.0	0.0	1.3	0.7
53.1	26.6	0.4	0.3
4.6	19.2	8.9	3.3
23.9	21.1	1.7	0.7
0.0	0.0	0.8	0.7
16.7	19.9	0.8	1.0
6.2	18.3	1.2	2.5
0.0	0.0	1.4	0.7
0.0	0.0	1.2	0.7
4.3	18.1	4.2	3.5
3.8	18.1	4.0	4.0
Average Enrichment (%)			1.91

Infer U-234 MDC using U-235 MDC + ratio of U-234/U-235 @ that sample's enrichment

0
0
0
3.787258
10.514611
7.797634
3.445319
3.861597
3.18344
4.402533
0
10.9491
4.127439
11.44249
0
7.186818
7.307894
0
0
2.974146
2.2273

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Step 8.6 Investigations

Elevated Measurement Comparison

[illegible]

NOTES:

Gross results in units of pCi/g

* Background with ingrowth (1.07 pCi/g) subtracted from gross result

**Background (1.0 pCi/g) subtracted from gross result

U qualifier: A normal, non-detected result (result less than MDC).

All uncertainty values are reported at the 2-sigma confidence level.

Step 8.6.7.c.

Step 8.6.7.e.

Step 8.6.7.f.1)

Step 8.6.7.f.2)

	DCGL _{EMC}	"clean" systematic samples δ_i	τ_i	$t_i - \delta_i$	f_{rel}
Ra-226	8.066	0.068	0.00	-0.068	-0.008
Tc-99	186.81	3.474	67.00	63.526	0.340
Th-232	5.4043	0.073	0.00	-0.073	-0.014
U-234	1419	2.548	19.56	17.012	0.012
U-235	119.03	0.081	1.08	0.999	0.008
U-238	546.07	1.212	3.37	2.158	0.004

Step 8.6.7.f.3) $f_{EMC} = \overline{0.342}$

Step 8.6.7.g. Summed elevated radioactivity fractions for the SU = 0.34 = EMC SOF

Step 8.6.7.h. Total SOF for the SU = 0.727 PASS

Step 8.6.7.i.

weighted SOF_{MEAN} 0.22

SOF _{MEAN} Re-use Backfill Material (used off-site BF)	0
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SOF_{MEAN} Groundwater 0.16

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Step 8.6 Investigations

Step 8.6.6	Bounding samples:	N/A
Step 8.6.7b		
Need area from GIS.	138	m ²

Step 8.6.7.a. DCLG_W, Uniform, Measure Tc-99, All SEAs

	Uniform
U-234	195.4
U-235	51.6
U-238	168.8
Tc-99	25.1
Th-232	2.0
Ra-226	1.9

Step 8.6.7b
Uniform Stratum

Radionuclide	Elevated Measurement Area (m ²)									
	153,375	10,000	3,000	1,000	300	100	30	10	3	1
U-234	1.0	1.2	1.3	1.3	4.0	9.3	19.6	34.3	70.5	132.8
U-235	1.0	1.1	1.1	1.1	1.9	2.5	3.3	4.7	9.6	20.5
U-238	1.0	1.1	1.3	1.3	2.5	3.6	5.0	7.2	14.9	31.6
Tc-99	1.0	1.0	1.0	1.0	3.4	10.3	34.3	102.9	342.7	1,027
Th-232	1.0	1.0	1.0	1.0	2.1	3.0	4.2	6.1	12.9	28.9
Ra-226	1.0	1.1	1.1	1.1	2.5	4.1	6.1	9.1	19.3	43.4

Interpolate

138
7.3
2.3
3.2
7.4
2.7
4.2

Step 8.6.7.e. δ_i = average concentration of systematic "clean" samples for each "elevated" nuclide

(Use corrected net results.)

Step 8.6.7.f.1) $\bar{c}_i$ = average concentration of elevated sample(s) for each ROC

Step 8.6.7.f.2) f_{elev} = elevated radioactivity fraction

$\frac{t_i - \delta_i}{\text{DCLG}_{\text{EMC}}}$

Step 8.6.7.f.3) Sum all f_{elev} (all ROCs in the elevated area) if applicable

Step 8.6.7.g. Sum all f_{EMC} (all elevated areas in the SU) if applicable

Step 8.6.7.h. Sum Step 8.6.7.g. and Step 8.4.5.g. ($\text{SOF}_{\text{MEAN,SU}}$ use total SOF SU (including GW, BF, etc.))

HDP-PR-FSS-721 *Final Status Survey Data Evaluation*
Step 8.6 Investigations

rd results:

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Step 8.6.7b. Area Factor Interpolation

The following equation is from "Decommissioning Health Physics: A Handbook for MARSSIM Users," p. 277, Abelquist, 2001, for interpolating Area Factors (AF) from the first existing AF under (smaller) than the desired area and the first existing AF over (larger) the desired area.

$$e^{\left[\frac{(\ln(\text{actual area}) - \ln(\text{under area}))(\ln(\text{over AF}) - \ln(\text{under AF}))}{\ln(\text{over area}) - \ln(\text{under area})} + \ln(\text{under AF}) \right]}$$

Ra-226 Excavation Area Factors		
	Area (m ²)	AF
Under	30	4.0
Over	100	2.0
Interpolated	40	3.39

Ra-226 Root Area Factors		
	Area (m ²)	AF
Under	100	3.9
Over	300	2.4
Interpolated	130	3.5

Tc-99 Excavation Area Factors		
	Area (m ²)	AF
Under	30	6.7
Over	100	2.0
Interpolated	40	5.02

Tc-99 Root Area Factors		
	Area (m ²)	AF
Under	100	10
Over	300	3.4
Interpolated	153	6.7

Th-232 Excavation Area Factors		
	Area (m ²)	AF
Under	30	3.0
Over	100	1.9
Interpolated	40	2.7

Th-232 Root Area Factors		
	Area (m ²)	AF
Under	100	3.0
Over	300	2.1
Interpolated	130	2.8

U-234 Excavation Area Factors		
	Area (m ²)	AF
Under	30	6.7
Over	100	2.0
Interpolated	40	5.0

U-234 Root Area Factors		
	Area (m ²)	AF
Under	100	9.4
Over	300	4.1
Interpolated	130	7.7

U-235 Excavation Area Factors		
	Area (m ²)	AF
Under	30	2.0
Over	100	1.3
Interpolated	40	1.8

U-235 Root Area Factors		
	Area (m ²)	AF
Under	100	2.3
Over	300	1.9
Interpolated	130	2.2

U-238 Excavation Area Factors		
	Area (m ²)	AF
Under	30	3.0
Over	100	1.9
Interpolated	40	2.7

U-238 Root Area Factors		
	Area (m ²)	AF
Under	100	3.6
Over	300	2.5
Interpolated	130	3.3

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Step 8.6.7b. Area Factor Interpolation

Ra-226 Surface Area Factors		
	Area (m²)	AF
Under	10	4.5
Over	30	3.0
Interpolated	13	4.08

Tc-99 Surface Area Factors		
	Area (m²)	AF
Under	10	102.2
Over	30	34.2
Interpolated	13	78.69

Th-232 Surface Area Factors		
	Area (m²)	AF
Under	10	3.5
Over	30	2.3
Interpolated	13	3.2

U-234 Surface Area Factors		
	Area (m²)	AF
Under	10	67.3
Over	30	41.7
Interpolated	13	60.0

U-235 Surface Area Factors		
	Area (m²)	AF
Under	10	2.6
Over	30	1.8
Interpolated	13	2.4

U-238 Surface Area Factors		
	Area (m²)	AF
Under	10	4.9
Over	30	3.4
Interpolated	13	4.5

Ra-226 Uniform Area Factors		
	Area (m²)	AF
Under	300	2.5
Over	1000	1.1
Interpolated	138	4.2

Tc-99 Uniform Area Factors		
	Area (m²)	AF
Under	100	10
Over	300	3.4
Interpolated	138	7.4

Th-232 Uniform Area Factors		
	Area (m²)	AF
Under	100	3.0
Over	300	2.1
Interpolated	138	2.7

U-234 Uniform Area Factors		
	Area (m²)	AF
Under	100	9.3
Over	300	4.0
Interpolated	138	7.3

U-235 Uniform Area Factors		
	Area (m²)	AF
Under	100	2.5
Over	300	1.9
Interpolated	138	2.3

U-238 Uniform Area Factors		
	Area (m²)	AF
Under	100	3.6
Over	300	2.5
Interpolated	138	3.2

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Step 8.6.7b. Area Factor Interpolation

Enter the appropriate AF from tables in HDP-PR-FSS-721 Appendix E:

1. Choose appropriate stratum
2. Choose elevated ROC
3. Enter appropriate Elevated Measurement Areas (m², Over and Under)
4. Enter area (m²) of elevated area to be Interpolated
5. Use Interpolated AF in Investigation worksheet

From HDP-PR-FSS-721, Appendix E Area Factors for Soil Contamination

Surface Stratum

Elevated Measurement Area (m²)

Radionuclide	153,375	10,000	3,000	1,000	300	100	30	10	3	1
U-234	1.0	1.5	2.2	2.6	7.8	19.3	41.7	67.3	96.0	119.5
U-235	1.0	1.1	1.2	1.2	1.3	1.5	1.8	2.6	5.4	12.1
U-238	1.0	1.2	1.5	1.6	2.2	2.6	3.4	4.9	10.2	22.3
Tc-99	1.0	1.0	1.0	1.0	3.4	10.3	34.2	102.2	338.5	1,009
Th-232	1.0	1.0	1.1	1.1	1.4	1.7	2.3	3.5	7.3	16.9
Ra-226	1.0	1.1	1.2	1.2	1.8	2.2	3.0	4.5	9.6	22.4

Root Stratum

Elevated Measurement Area (m²)

Radionuclide	153,375	10,000	3,000	1,000	300	100	30	10	3	1
U-234	1.0	1.2	1.3	1.4	4.1	9.4	19.2	33.0	67.9	130.4
U-235	1.0	1.0	1.1	1.1	1.9	2.3	2.9	4.1	8.3	17.9
U-238	1.0	1.1	1.3	1.3	2.5	3.6	5.0	7.2	14.8	31.5
Tc-99	1.0	1.0	1.0	1.0	3.4	10.3	34.3	103.0	343.3	1,029
Th-232	1.0	1.0	1.0	1.0	2.1	3.0	4.2	6.0	12.8	28.4
Ra-226	1.0	1.0	1.1	1.1	2.4	3.9	5.8	8.7	18.5	41.6

Excavation Stratum

Elevated Measurement Area (m²)

Radionuclide					148	100	30	10	3	1
U-234					1.0	2.0	6.7	19	35	65
U-235					1.0	1.3	2	2	4	7
U-238					1.0	1.9	3	4	7	13
Tc-99					1.0	2.0	6.7	20	67	200
Th-232					1.0	1.9	3	4	7	14
Ra-226					1.0	2.0	4	5	10	20

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Step 8.6.7b. Area Factor Interpolation

Uniform Stratum										
	Elevated Measurement Area (m ²)									
Radionuclide	153,375	10,000	3,000	1,000	300	100	30	10	3	1
U-234	1.0	1.2	1.3	1.3	4.0	9.3	19.6	34.3	70.5	132.8
U-235	1.0	1.1	1.1	1.1	1.9	2.5	3.3	4.7	9.6	20.5
U-238	1.0	1.1	1.3	1.3	2.5	3.6	5.0	7.2	14.9	31.6
Tc-99	1.0	1.0	1.0	1.0	3.4	10.3	34.3	102.9	342.7	1,027
Th-232	1.0	1.0	1.0	1.0	2.1	3.0	4.2	6.1	12.9	28.9
Ra-226	1.0	1.1	1.1	1.1	2.5	4.1	6.1	9.1	19.3	43.4

Change area if it is incorrect. Make sure "over" and "under" correlate for all six nuclides.

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Step 8.5 Performance of Statistical Tests

WRS TEST					
SAMPLE ID	AREA (Reference, Survey Unit)	Gross SOF ($X_{i,ref}$, $Y_{i,SU}$) Step 8.5.3a	ADJUSTED SOF (Z_i) Step 8.5.3b	RANKS Step 8.5.3d	REFERENCE AREA RANKS
9574-SS-140910-01-01	Reference	1.31	2.310	48	48
9574-SS-140910-01-02	Reference	1.18	2.179	39	39
9574-SS-140910-01-03	Reference	1.06	2.064	34	34
9574-SS-140910-01-04	Reference	1.10	2.101	35	35
9574-SS-140910-01-05	Reference	1.29	2.293	47	47
9574-SS-140910-01-07	Reference	1.34	2.339	49	49
9574-SS-140910-01-08	Reference	1.15	2.154	38	38
9574-SS-140910-01-09	Reference	1.18	2.182	40	40
9574-SS-140910-01-10	Reference	1.23	2.227	45	45
9574-SS-140910-01-11	Reference	1.38	2.380	50	50
9574-SS-140910-01-12	Reference	1.05	2.055	33	33
9574-SS-140910-01-13	Reference	0.94	1.941	23	23
9574-SS-140910-01-14	Reference	1.12	2.119	36	36
9574-SS-140910-01-15	Reference	1.15	2.152	37	37
9574-SS-140910-01-16	Reference	1.03	2.028	30	30
9574-SS-140910-01-17	Reference	0.44	1.443	16	16
9574-SS-140910-01-18	Reference	1.19	2.188	42	42
9574-SS-140910-01-20	Reference	0.76	1.757	18	18
9574-SS-140910-01-21	Reference	1.02	2.023	29	29
9574-SS-140910-01-22	Reference	1.02	2.018	28	28
9574-SS-140910-01-23	Reference	1.00	2.002	25	25
9574-SS-140910-01-24	Reference	0.87	1.873	20	20
9574-SS-140910-01-25	Reference	1.04	2.040	32	32
9574-SS-140910-01-26	Reference	0.96	1.959	24	24
9574-SS-140910-01-27	Reference	1.20	2.204	43	43
9574-SS-140910-01-28	Reference	1.01	2.007	27	27
9574-SS-140910-01-29	Reference	1.22	2.223	44	44
9574-SS-140910-01-30	Reference	1.03	2.035	31	31
9574-SS-140910-01-31	Reference	1.00	2.005	26	26
9574-SS-140910-01-32	Reference	0.86	1.865	19	19
9574-SS-140910-01-33	Reference	1.24	2.238	46	46
9574-SS-140910-01-34	Reference	1.19	2.185	41	41
L08-10-01-T-S-S-00	Survey Unit	0.75	0.753	3	0
L08-10-02-T-R-S-00	Survey Unit	0.90	0.897	6	0
L08-10-04-T-S-S-00	Survey Unit	0.98	0.981	7	0
L08-10-05-T-R-S-00	Survey Unit	1.44	1.439	15	0
L08-10-07-T-S-S-00	Survey Unit	1.34	1.337	14	0
L08-10-08-T-R-S-00	Survey Unit	1.28	1.282	11	0
L08-10-10-T-S-S-00	Survey Unit	0.85	0.851	5	0
L08-10-11-T-R-S-00	Survey Unit	1.93	1.926	21	0
L08-10-12-T-E-S-00	Survey Unit	1.12	1.117	9	0
L08-10-13-T-S-S-00	Survey Unit	1.94	1.936	22	0
L08-10-14-T-R-S-00	Survey Unit	1.33	1.326	13	0
L08-10-16-T-S-S-00	Survey Unit	0.73	0.727	2	0
L08-10-17-T-R-S-00	Survey Unit	1.74	1.743	17	0
L08-10-18-T-E-S-00	Survey Unit	1.26	1.256	10	0
L08-10-19-T-S-S-00	Survey Unit	0.76	0.765	4	0
L08-10-20-T-R-S-00	Survey Unit	1.09	1.086	8	0
L08-10-22-T-S-S-00	Survey Unit	0.55	0.553	1	0
L08-10-23-T-R-S-00	Survey Unit	1.32	1.321	12	0
Rank Sums				1275	1095
# Reference Area Measurements				m	32
# Survey Unit Measurements				n	18
Total Number of Measurements Step 8.5.3c				N	50
(1-α) percentile of a standard normal distribution (MARSSIM Pg. I-10)				z	1.645
WRS Critical Value (MARSSIM Pg. I-10, Eq. I.1)				CV	898

Step 8.5.1
Min adjusted bkg SOF
1.44

No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
Perform WRS test
No WRS test necessary
Perform WRS test
No WRS test necessary
No WRS test necessary
Perform WRS test
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary
No WRS test necessary

W_r Step 8.5.3e

$\alpha = 0.05$

TEST: **PASS** Step 8.5.3f

HDP-PR-FSS-701 Final Status Survey Plan Development

Appendix B.1 Step 8 Calculate the Number of Samples in the Statistical Population

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	SOF (Ra/Tc/Th/Iso U)
St. Dev.	0.24
DCGL _{SOF}	1
LBGR (Mean)	0.22
Shift	0.78
Relative Shift (Δ/σ)	3.27
MARSSIM Table 5.1 (P_r)	0.983039
N	13
N + 20%	15.6
N/2	8
FSS N/2	8
Verification Check	SUFFICIENT MEASUREMENTS
"N/2" Corresponds to the number of survey unit measurement locations required for the WRS Test	

MARSSIM Table 5.1

Δ/σ	P_r
0.1	0.528182
0.2	0.556223
0.3	0.583985
0.4	0.611335
0.5	0.638143
0.6	0.664290
0.7	0.689665
0.8	0.714167
0.9	0.737710
1.0	0.760217
1.1	0.781627
1.2	0.801892
1.3	0.820978
1.4	0.838864
1.5	0.855541
1.6	0.871014
1.7	0.885299
1.8	0.898420
1.9	0.910413
2.0	0.921319
2.25	0.944167
2.5	0.961428
2.75	0.974067
3.0	0.983039
3.5	0.993329
4.0	0.997658
4.01	1.000000

MARSSIM Table 5.2, $\alpha = 0.05$, $\beta = 0.10$

α (or β)	$Z_{1-\alpha}$ (or $Z_{1-\beta}$)
0.005	2.576
0.01	2.326
0.015	2.241
0.025	1.960
0.05	1.645
0.10	1.282
0.15	1.036
0.2	0.842
0.25	0.674
0.30	0.524

α
 β

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control											
								Revision: 2		Page 1 of 1		
FORM HDP-PR-FSS-703-1 FIELD DUPLICATE SAMPLE ASSESSMENT												
Survey Unit No.:	LSA 08-10				Survey Unit Description:	Central Open Land Area in "Area 6"						
Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{x}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic ²	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
			Activity (x_i)	MDC	Activity (x_i)	MDC						
L08-10-05-T-R-S-00	L08-10-05-T-R-Q-00	Ra-226	1.16	0.0677	0.993	0.0861	1.077	1.9	0.167	0.269	0.403	N
L08-10-05-T-R-S-00	L08-10-05-T-R-Q-00	Tc-99	7.41	0.204	4.11	0.238	5.760	25.1	3.3	3.552	5.321	N
L08-10-05-T-R-S-00	L08-10-05-T-R-Q-00	Th-232	0.966	0.137	0.648	0.219	0.807	2.0	0.318	0.283	0.424	Y
L08-10-05-T-R-S-00	L08-10-05-T-R-Q-00	U-234 ¹	6.687	N/A	1.240	N/A	3.963	195.4	5.447	27.649	41.425	N
L08-10-05-T-R-S-00	L08-10-05-T-R-Q-00	U-235	0.369	0.209	-0.114	0.64	0.128	51.6	NA	7.301	10.939	NA
L08-10-05-T-R-S-00	L08-10-05-T-R-Q-00	U-238	1.52	0.811	1.24	0.975	1.380	168.8	0.280	23.885	35.786	N
Comments: 1. U-234 is inferred, no MDC available. 2. Duplicate assessment is not necessary if the result of either sample is < MDC.												
Performed by: _____						Reviewed by: _____						
Date: _____						Date: _____						
Quality Record												

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control											
								Revision: 2		Page 1 of 1		

FORM HDP-PR-FSS-703-1 FIELD DUPLICATE SAMPLE ASSESSMENT												
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Survey Unit No.:	LSA 08-10				Survey Unit Description:	Central Open Land Area in "Area 6"						
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Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{x}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic ²	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
			Activity (x_i)	MDC	Activity (x_i)	MDC						
L08-10-16-T-S-S-00	L08-10-16-T-S-Q-00	Ra-226	0.532	0.129	0.8	0.0603	0.666	1.9	0.268	0.269	0.403	N
L08-10-16-T-S-S-00	L08-10-16-T-S-Q-00	Tc-99	1.87	0.215	3.86	0.22	2.865	25.1	1.99	3.552	5.321	N
L08-10-16-T-S-S-00	L08-10-16-T-S-Q-00	Th-232	0.73	0.0843	0.718	0.0765	0.724	2.0	0.012	0.283	0.424	N
L08-10-16-T-S-S-00	L08-10-16-T-S-Q-00	U-234 ¹	0.445	N/A	4.189	N/A	2.317	195.4	3.744	27.649	41.425	N
L08-10-16-T-S-S-00	L08-10-16-T-S-Q-00	U-235	0.0167	0.411	0.231	0.164	0.124	51.6	NA	7.301	10.939	NA
L08-10-16-T-S-S-00	L08-10-16-T-S-Q-00	U-238	0.887	0.672	0.999	0.725	0.943	168.8	0.112	23.885	35.786	N

Comments:

1. U-234 is inferred, no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: _____

Date: _____

Reviewed by: _____

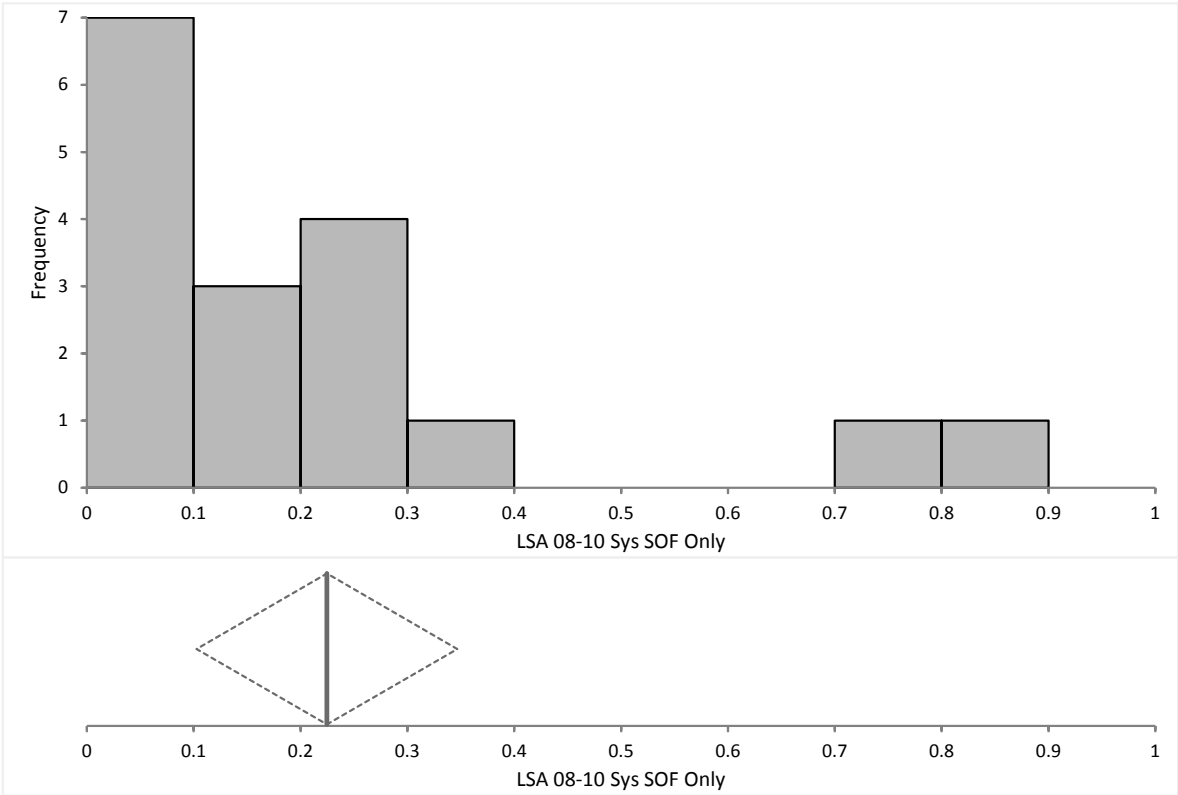
Date: _____

Quality Record

LSA 08-10 Sys SOF Only

0.0
0.0
0.1
0.4
0.3
0.2
0.1
0.9
0.2
0.3
0.1
0.7
0.2
0.1
0.0
0.0
0.3

Descriptives



N 17								
	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 08-10 Sys SOF Only	0.22	0.10 to 0.35		0.058	0.24	0.06	1.8	2.86
	Minimum	1st quartile	Median	95.1% CI		3rd quartile	Maximum	IQR
LSA 08-10 Sys SOF Only	0.0	0.07	0.18	0.08 to 0.26		0.27	0.9	0.20