

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 05	Description:	Barns and Cistern Open Land Area
Survey Unit:	03	Description:	Red Barn Area
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
L050301PRS00	Uniform	S	434.9	431.7	864773.6	826747.6	Root Zone Composite
L050302PES00	Uniform	S	431.7	431.2	864773.6	826747.6	Excavation 6-in Grab
L050303PRS00	Uniform	S	435.9	432.5	864784.6	826706.5	Root Zone Composite
L050304PES00	Uniform	S	432.5	432.0	864784.6	826706.5	Excavation 6-in Grab
L050305PRS00	Uniform	S	434.6	433.9	864803.6	826777.6	Root Zone Composite
L050306PES00	Uniform	S	433.9	433.4	864803.6	826777.6	Excavation 6-in Grab
L050307PRS00	Uniform	S	435.7	433.7	864814.6	826736.6	Root Zone Composite
L050308PES00	Uniform	S	433.7	433.2	864814.6	826736.6	Excavation 6-in Grab
L050309PRS00	Uniform	S	434.7	434.2	864833.7	826807.7	Root Zone Composite
L050310PES00	Uniform	S	434.2	433.7	864833.7	826807.7	Excavation 6-in Grab
L050311PRS00	Uniform	S	435.6	434.6	864844.7	826776.6	Root Zone Composite
L050312PES00	Uniform	S	434.6	434.1	864844.7	826776.6	Excavation 6-in Grab
L050313PRS00	Uniform	S	438.1	437.3	864855.7	826725.6	Root Zone Composite
L050314PES00	Uniform	S	437.3	436.8	864855.7	826725.6	Excavation 6-in Grab
L050315PRS00	Uniform	S	435.1	433.9	864863.7	826837.7	Root Zone Composite
L050316PES00	Uniform	S	433.9	433.4	864863.7	826837.7	Excavation 6-in Grab
L050317PRS00	Uniform	S	435.5	433.9	864874.7	826796.7	Root Zone Composite
L050318PES00	Uniform	S	433.9	433.4	864874.7	826796.7	Excavation 6-in Grab
L050319PRS00	Uniform	S	439.1	437.0	864885.7	826755.6	Root Zone Composite
L050320PES00	Uniform	S	437.0	436.5	864885.7	826755.6	Excavation 6-in Grab
L050321PRS00	Uniform	S	436.6	435.1	864904.8	826826.7	Root Zone Composite
L050322PES00	Uniform	S	435.1	434.6	864904.8	826826.7	Excavation 6-in Grab
L050304PEQ00	Uniform	Q	432.5	432.0	864784.6	826706.5	QA Duplicate Sample
L050323PUB00	Uniform	B	434.6	434.1	864823.3	826718.4	Biased 6-in Grab
L050324PUB00	Uniform	B	434.8	434.3	864891.7	826783.8	Biased 6-in Grab
L050325PUB00	Uniform	B	434.7	434.2	864907.2	826827.6	Biased 6-in Grab
L050343PUB00	Uniform	B	432.8	432.3	864811.5	826707.6	Biased 6-in Grab
L050344PUB00	Uniform	B	431.2	430.7	864780.1	826739.2	Biased 6-in Grab
L050345PUB00	Uniform	B	435.8	435.3	864825.9	826699.6	Biased 6-in Grab
L050346PUB00	Uniform	B	432.8	432.3	864811.5	826707.6	Biased 6-in Grab
L050347PUB00	Uniform	B	431.2	430.7	864780.1	826739.2	Biased 6-in Grab
L050348PUB00	Uniform	B	435.8	435.3	864825.9	826699.6	Biased 6-in Grab
L050349PUB00	Uniform	B	430.1	429.6	864765.2	826730.7	Biased 6-in Grab
L050350PUB00	Uniform	B	431.9	431.4	864783.4	826701.3	Biased 6-in Grab
L050351PUB00	Uniform	B	432.9	432.4	864809.5	826704.5	Biased 6-in 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)

			TestAmerica Analytical Results Step 8.3.2																																		Root Stratum SOF Verification (see worksheet backsheet only) Step 8.4.4.1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
Sample ID	Sample Start Depth (ft)	Type (Systematic Bias, Q)	Ra-226										Tc-99										Th-232										Inferred U-234										U-235										U-238										Env.	SOF _{PR} Step 8.4.3	Step	Root Stratum SOF Verification (see worksheet backsheet only) Step 8.4.4.1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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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)

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

MDC DEP Step 8.1.6
0.30
0.24
0.25
0.28
0.22
0.22
0.22
0.26
0.21
0.23
0.27
0.23
0.22
0.20
0.27
0.22
0.25
0.22
0.20
0.24
0.32
0.26
0.21
0.22
0.22
0.24
0.27
0.25
0.21
0.24
0.21
0.23
0.19
0.21
0.22

Step 8.4.1 DCLG₅₀ 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 8.4.5b

Weighted SOF_{DEAN} 0.12

	SS	RS	ES
Fractions	0.045454545	0.954545455	0

Step 8.4.5c SOF_{Re-use Backfill Material}
0 Offsite borrow (No contribution)

Step 8.4.5e SOF_{Re-use Groundwater}

0.16

Step 8.4.5g (<=1)

SOF_{WEAK, SU} 0.28 PASS

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

7.0 mrem

Infer U234 Step 8.3.4			
U-238/U235 Ratio	U-234/U235 Ratio	U-234	% Enrichment
7.9	18.5	2.6	2.0
19.9	18.9	2.6	1.5
17.2	20.2	1.1	0.9
5.1	18.2	7.5	3.0
9.5	18.7	3.2	1.7
35.1	22.7	0.6	0.5
8.5	18.7	3.5	1.8
12.3	19.2	2.1	1.3
41.7	24.2	0.8	0.4
8.6	18.7	1.9	1.8
5.0	18.2	2.9	3.1
8.8	18.7	2.9	1.6
8.0	18.5	3.1	2.0
6.2	18.3	3.7	2.5
12.0	19.2	2.4	1.3
32.0	22.7	0.6	0.5
19.0	20.2	0.9	0.9
14.9	19.6	2.1	1.1
20.1	20.6	0.9	0.8
9.2	18.7	4.8	1.7
20.7	20.6	1.5	0.8
14.7	19.6	1.8	1.1
10.4	18.9	1.7	1.5
7.3	18.5	4.0	2.1
22.4	21.1	1.2	0.7
18.3	19.6	2.3	1.0
19.8	20.6	2.1	0.8
15.5	19.9	2.3	1.0
6.2	18.3	6.0	2.5
16.1	19.9	2.4	1.0
4.6	18.2	3.5	3.3
6.6	18.4	5.2	2.3
7.8	18.5	3.2	2.0
13.1	19.4	2.3	1.2
11.8	18.1	2.9	1.4
Average Enrichment (%)			1.48

Infer U-234 MDC using U- 235 MDC * ratio of U-234/U-235 @ that sample's enrichment
22.98
19.89
20.06
20.20
18.93
20.97
20.53
16.39
19.79
22.40
16.62
17.17
15.92
18.68
18.45
22.96
19.70
18.91
19.76
41.99
21.18
21.76
15.40
16.37
23.39
19.92
19.49
19.58
15.35
18.36
15.65
19.12
14.97
18.90
18.61

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)

[illegible]

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 ($X_{i,ref}$, $Y_{i,SU,gross}$) 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	52	52
9574-SS-140910-01-02	Reference	1.18	2.179	43	43
9574-SS-140910-01-03	Reference	1.06	2.064	38	38
9574-SS-140910-01-04	Reference	1.10	2.101	39	39
9574-SS-140910-01-05	Reference	1.29	2.293	51	51
9574-SS-140910-01-07	Reference	1.34	2.339	53	53
9574-SS-140910-01-08	Reference	1.15	2.154	42	42
9574-SS-140910-01-09	Reference	1.18	2.182	44	44
9574-SS-140910-01-10	Reference	1.23	2.227	49	49
9574-SS-140910-01-11	Reference	1.38	2.380	54	54
9574-SS-140910-01-12	Reference	1.05	2.055	37	37
9574-SS-140910-01-13	Reference	0.94	1.941	27	27
9574-SS-140910-01-14	Reference	1.12	2.119	40	40
9574-SS-140910-01-15	Reference	1.15	2.152	41	41
9574-SS-140910-01-16	Reference	1.03	2.028	34	34
9574-SS-140910-01-17	Reference	0.44	1.443	23	23
9574-SS-140910-01-18	Reference	1.19	2.188	46	46
9574-SS-140910-01-20	Reference	0.76	1.757	24	24
9574-SS-140910-01-21	Reference	1.02	2.023	33	33
9574-SS-140910-01-22	Reference	1.02	2.018	32	32
9574-SS-140910-01-23	Reference	1.00	2.002	29	29
9574-SS-140910-01-24	Reference	0.87	1.873	26	26
9574-SS-140910-01-25	Reference	1.04	2.040	36	36
9574-SS-140910-01-26	Reference	0.96	1.959	28	28
9574-SS-140910-01-27	Reference	1.20	2.204	47	47
9574-SS-140910-01-28	Reference	1.01	2.007	31	31
9574-SS-140910-01-29	Reference	1.22	2.223	48	48
9574-SS-140910-01-30	Reference	1.03	2.035	35	35
9574-SS-140910-01-31	Reference	1.00	2.005	30	30
9574-SS-140910-01-32	Reference	0.86	1.865	25	25
9574-SS-140910-01-33	Reference	1.24	2.238	50	50
9574-SS-140910-01-34	Reference	1.19	2.185	45	45
L050301PRS00	Survey Unit	1.26	1.264	20	0
L050302PES00	Survey Unit	1.30	1.296	21	0
L050303PRS00	Survey Unit	1.16	1.164	10	0
L050304PES00	Survey Unit	1.40	1.402	22	0
L050305PRS00	Survey Unit	1.17	1.171	12	0
L050306PES00	Survey Unit	1.14	1.136	7	0
L050307PRS00	Survey Unit	1.20	1.203	17	0
L050308PES00	Survey Unit	1.18	1.179	16	0
L050309PRS00	Survey Unit	1.02	1.017	1	0
L050310PES00	Survey Unit	1.14	1.144	8	0
L050311PRS00	Survey Unit	1.17	1.166	11	0
L050312PES00	Survey Unit	1.18	1.176	14	0
L050313PRS00	Survey Unit	1.14	1.136	6	0
L050314PES00	Survey Unit	1.18	1.176	15	0
L050315PRS00	Survey Unit	1.15	1.154	9	0
L050316PES00	Survey Unit	1.24	1.238	19	0
L050317PRS00	Survey Unit	1.21	1.213	18	0
L050318PES00	Survey Unit	1.07	1.072	3	0
L050319PRS00	Survey Unit	1.17	1.174	13	0
L050320PES00	Survey Unit	1.11	1.107	4	0
L050321PRS00	Survey Unit	1.07	1.071	2	0
L050322PES00	Survey Unit	1.12	1.123	5	0
Rank Sums				1485	1232
# Reference Area Measurements				m	32
# Survey Unit Measurements				n	22
Total Number of Measurements Step 8.5.3c				N	54
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	974

Min adjusted bkg SOF:	1.44
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[illegible]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 P-1 Step 8. Calculate the Number of Samples in the Statistical Survey Population

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	SOF (Ra/Tc/Th/Iso U)
St. Dev.	0.07
DCGL _{SOF}	1
LBGR (Mean)	0.12
Shift	0.88
Relative Shift (Δ/σ)	11.97
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
N/2	8
FSS N/2	11
Verification Check	SUFFICIENT MEASUREMENTS
<p>"N/2" Corresponds to the number of survey unit measurement locations required for the WRS Test</p>	

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

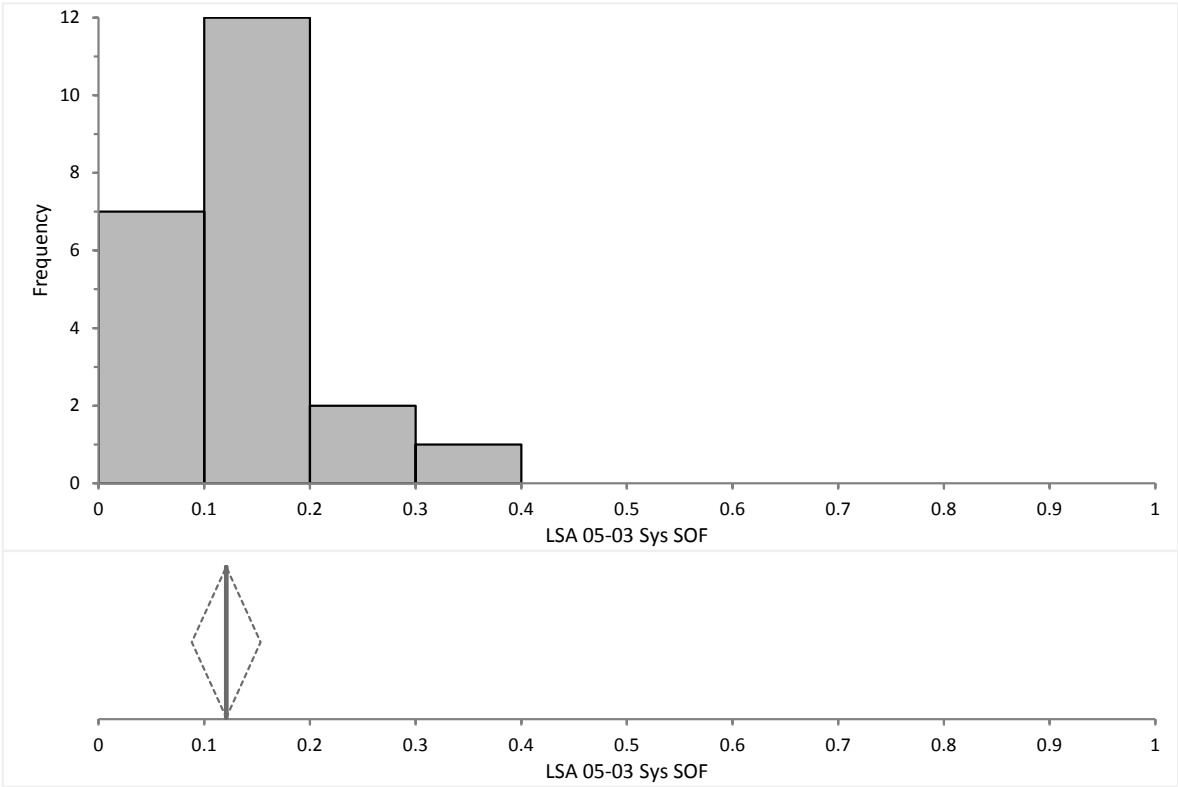
α
 β

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control											
							Revision: 2		Page 1 of 1			
<p align="center">FORM HDP-PR-FSS-703-1 FIELD DUPLICATE SAMPLE ASSESSMENT</p>												
Survey Unit No.:		LSA 05-03			Survey Unit Description:		Red Barn Area					
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						
L050304PES00	L050304PEQ00	Ra-226	1.44	0.0964	1.26	0.0828	1.35	1.9	0.18	0.269	0.403	N
L050304PES00	L050304PEQ00	Tc-99	-0.0618	0.26	-0.0875	0.245	-0.07465	25.1	NA	3.552	5.321	NA
L050304PES00	L050304PEQ00	Th-232	1.18	0.18	1.27	0.127	1.225	2.0	0.090	0.283	0.424	N
L050304PES00	L050304PEQ00	U-234 ¹	7.242	NA	1.737	NA	4.490	195.4	5.505	27.649	41.425	N
L050304PES00	L050304PEQ00	U-235	0.40	1.11	0.09	0.813	0.245	51.6	NA	7.301	10.939	NA
L050304PES00	L050304PEQ00	U-238	2.02	1.11	0.956	0.813	1.488	168.8	1.064	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: Thomas Yardy						Reviewed by: Clark Evers						
Date:						Date:						
Quality Record												

LSA 05-03 Sys SOF

0.2
0.2
0.1
0.3
0.1
0.1
0.1
0.1
0.1
0.0
0.1
0.1
0.1
0.1
0.1
0.1
0.2
0.2
0.0
0.1
0.1
0.0
0.1

Descriptives



N		22							
		Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 05-03 Sys SOF		0.12	0.09 to 0.15		0.016	0.07	0.01	1.3	2.87
		Minimum	1st quartile	Median	98.31% CI		3rd quartile	Maximum	IQR
LSA 05-03 Sys SOF		0.01	0.08	0.11	0.08 to 0.15		0.15	0.3	0.07