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|--|---|--------------|---------------------------|
| Hematite Decommissioning Project | Procedure: HDP-PR-FSS-701, Final Status Survey Plan Development | | |
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APPENDIX P-4

FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

| | | | |
|---------------------|---------------|------------------------|------------------------------------|
| Survey Area: | <u>BSA 04</u> | Description: | <u>Rail Line in 09-03</u> |
| Survey Unit: | <u>17</u> | Description: | <u>Rail Line (Tracks and Ties)</u> |
| Survey Type: | <u>FSS</u> | Classification: | <u>Class 1</u> |

| Measurement or Sample ID | Surface or CSM | Type | Start Elevation | End Elevation | Northing (feet) (Y Axis) * | Easting (feet) (X Axis) * | Remarks / Notes |
|--------------------------|----------------|------|-----------------|---------------|-------------------------------|------------------------------|-----------------|
| B04-17-01-S-F-S-00 | F | S | 434.8 | 434.8 | 864626.8 | 827356.2 | Rail Line |
| B04-17-02-S-F-S-00 | F | S | 434.8 | 434.8 | 864626.8 | 827369.0 | Rail Line |
| B04-17-03-S-F-S-00 | F | S | 434.8 | 434.8 | 864637.9 | 827375.4 | Rail Line |
| B04-17-04-S-F-S-00 | F | S | 434.8 | 434.8 | 864649.1 | 827394.6 | Rail Line |
| B04-17-05-S-F-S-00 | F | S | 434.8 | 434.8 | 864660.2 | 827401.0 | Rail Line |
| B04-17-06-S-F-S-00 | F | S | 434.8 | 434.8 | 864671.4 | 827420.2 | Rail Line |
| B04-17-07-S-F-S-00 | F | S | 434.8 | 434.8 | 864682.5 | 827439.4 | Rail Line |
| B04-17-08-S-F-S-00 | F | S | 434.8 | 434.8 | 864693.7 | 827445.8 | Rail Line |
| B04-17-09-S-F-S-00 | F | S | 434.8 | 434.8 | 864693.7 | 827458.6 | Rail Line |
| B04-17-10-S-F-S-00 | F | S | 434.8 | 434.8 | 864704.8 | 827465.0 | Rail Line |
| B04-17-11-S-F-S-00 | F | S | 434.8 | 434.8 | 864716.0 | 827484.2 | Rail Line |

*X and Y coordinates are provided using Missouri - East State Plane Coordinates [North American Datum (NAD) 1983] (Open Land Area)

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

CSM: Three-Layer (Surface-Root-Deep) or Uniform

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

Quality Record

| | | | | | | |
|-----------------------|-----------------------|--|----------------------------------|---------------------------------|--------------------------------|--------------------------------|
| Ludlum 2360 237312 | Ludlum 43-89 19207 | Active Probe Area 125 cm ² | α HDP Efficiency 24.1% | α Cal. Efficiency N/A | β HDP Efficiency 8.5% | β Cal. Efficiency N/A |
|-----------------------|-----------------------|--|----------------------------------|---------------------------------|--------------------------------|--------------------------------|

TOTAL WEIGHTED INSTRUMENT EFFICIENCY CALCULATION

| Radionuclide | Radiation | Maximum Energy (MeV) | Instrument Efficiency (ϵ_i) | Surface Efficiency (ϵ_s) | Yield 100% | Activity Fraction | Weighted Efficiency |
|--------------|-----------|----------------------|--|-------------------------------------|------------|-------------------|---------------------|
| Am-241 | Alpha | 5.6 | 0.2409 | 0.25 | 1.00 | 2.682E-03 | 1.62E-04 |
| Np-237 | Alpha | 5.0 | 0.2409 | 0.25 | 1.00 | 5.573E-05 | 3.36E-06 |
| Pu-239 | Alpha | 5.2 | 0.2409 | 0.25 | 1.00 | 2.027E-06 | 1.22E-07 |
| Tc-99 | Beta | 0.294 | 0.0854 | 0.25 | 1.00 | 2.829E-03 | 6.04E-05 |
| Th-232 | Alpha | 4.1 | 0.2409 | 0.25 | 1.00 | 3.214E-03 | 1.94E-04 |
| Ra-228 | Beta | 0.046 | 0.0854 | 0.00 | 1.00 | 3.214E-03 | 0.00E+00 |
| Ac-228 | Beta | 2.13 | 0.0854 | 0.50 | 1.00 | 3.214E-03 | 1.37E-04 |
| Th-228 | Alpha | 5.5 | 0.2409 | 0.25 | 1.00 | 3.214E-03 | 1.94E-04 |
| Ra-224 | Alpha | 5.8 | 0.2409 | 0.25 | 1.00 | 3.214E-03 | 1.94E-04 |
| U-234 | Alpha | 4.9 | 0.2409 | 0.25 | 1.00 | 8.270E-01 | 4.98E-02 |
| U-235 | Alpha | 4.7 | 0.2409 | 0.25 | 1.00 | 3.720E-02 | 2.24E-03 |
| Th-231 | Beta | 0.390 | 0.0854 | 0.25 | 1.00 | 3.720E-02 | 7.94E-04 |
| U-238 | Alpha | 4.3 | 0.2409 | 0.25 | 1.00 | 1.270E-01 | 7.65E-03 |
| Th-234 | Beta | 0.270 | 0.0854 | 0.25 | 1.00 | 1.270E-01 | 2.71E-03 |
| Pa-234m | Beta | 2.20 | 0.0854 | 0.50 | 1.00 | 1.270E-01 | 5.42E-03 |

Total Weighted Instrument Efficiency = Σ Weighted Instrument Efficiency for all Nuclides of Concern

$\Sigma =$ 6.96%

Weighted Instrument Efficiency = $\epsilon_i * \epsilon_s * \text{Yield} * \text{Activity Fraction}$

ϵ_i = 2 Pi Instrument Efficiency for Nuclide of Concern

ϵ_s = Surface Efficiency for Nuclide of Concern

| |
|-------------------------------|
| <p>Meter 43-89</p> |
|-------------------------------|

HDP-PR-FSS-721 Final Status Survey Data Evaluation
Preliminary Data Review and Determination of Sum-of-Fractions (SOF)

| MEASUREMENT ID | MEASUREMENT LOCATION | DATE MEAS | MEASUREMENT | Step 8.3.2 | | | | Corrected Net dpm/100cm ² | Fraction of DCGL Step 8.4.3 |
|--------------------|----------------------|------------|------------------|-----------------------|---------------------|-----------------------|--|---|-----------------------------------|
| | | | | GROSS cpm (α+β) | BKG cpm (a+b) | Net cpm (α + β) | Combined Net dpm/100 cm ² (α+β) | | |
| B04-17-01-S-F-S-00 | Rail Line | 05/12/2016 | alpha + beta TSC | 253 | 208 | 44.667 | 513 | 513 | 3% |
| B04-17-02-S-F-S-00 | Rail Line | 05/12/2016 | alpha + beta TSC | 324 | 208 | 115.67 | 1330 | 1330 | 7% |
| B04-17-03-S-F-S-00 | Rail Line | 05/12/2016 | alpha + beta TSC | 255 | 208 | 46.667 | 536 | 536 | 3% |
| B04-17-04-S-F-S-00 | Rail Line | 05/12/2016 | alpha + beta TSC | 208 | 208 | -0.333 | -4 | 0 | 0% |
| B04-17-05-S-F-S-00 | Rail Line | 05/12/2016 | alpha + beta TSC | 190 | 208 | -18.33 | -211 | 0 | 0% |
| B04-17-06-S-F-S-00 | Rail Line | 05/12/2016 | alpha + beta TSC | 215 | 208 | 6.6667 | 77 | 77 | 0% |
| B04-17-07-S-F-S-00 | Rail Line | 05/12/2016 | alpha + beta TSC | 214 | 208 | 5.6667 | 65 | 65 | 0% |
| B04-17-08-S-F-S-00 | Rail Line | 05/12/2016 | alpha + beta TSC | 176 | 208 | -32.33 | -372 | 0 | 0% |
| B04-17-09-S-F-S-00 | Rail Line | 05/12/2016 | alpha + beta TSC | 209 | 208 | 0.6667 | 8 | 8 | 0% |
| B04-17-10-S-F-S-00 | Rail Line | 05/12/2016 | alpha + beta TSC | 237 | 208 | 28.667 | 330 | 330 | 2% |
| B04-17-11-S-F-S-00 | Rail Line | 05/12/2016 | alpha + beta TSC | 240 | 208 | 31.667 | 364 | 364 | 2% |

*NOTE: Differences from documented survey results are due to rounding in Excel

| | | | |
|--------|-------|--------|---------------------------|
| Min | 0 | 2% | Average Fraction |
| Max | 1330 | | Step 8.4.5.g |
| Mean | 293 | DCGLso | |
| Median | 77 | 0.4 | mrem SU Dose Contribution |
| Stdev | 403.3 | mrem | Step 8.4.6 |

Instrument used for FSS Static Measurements:

| | | | |
|---------------------------------|--|----------------------------------|------------------------|
| Ludlum 2360/43-89 | S/N 237312 | 05/12/2016 | Survey # 7475 C 160512 |
| Detector Area (A) = | 125 cm ² | ave. ambient bkg = | 208.3 cpm |
| | | weighted eff (ε _w) = | 0.06960 |
| | | (α + β) | |
| TSC (dpm/100cm ²) = | (acpm-bka) / (ε _w * (A _{net} /100 cm ²)) | | |
| DCGL (structures) = | 18.925 dpm/100 cm ² | | |

HDP-PR-HP-314 Unrestricted Release of Materials and Equipment
Removable Data Evaluation

Instrument used for Removable Measurements:

Tennelec Unit #1 Batch # 52190 ##### Survey # 7475 C 160512

alpha bkg = 0.5 cpm alpha efficiency = 25.30% alpha MDA = 12
beta bkg = 2.8 cpm beta efficiency = 25.40% beta MDA = 24.7

| MEASUREMENT ID | MEASUREMENT LOCATION | DATE MEAS | Alpha Gross cpm | Alpha Net cpm | Alpha Net dpm/100cm ² | Corrected Alpha Net dpm/100cm ² | Beta Gross cpm | Beta Net cpm | Beta Net dpm/100cm ² | Corrected Beta Net dpm/100cm ² | Combined Net dpm/100 cm ² (α+β) | Exceed 10% of Min. Sys. TSC Result? | Exceed MDA? | Exceed 10% of DCGL? |
|----------------|----------------------|------------|--------------------|------------------|-------------------------------------|--|-------------------|-----------------|------------------------------------|---|--|---|----------------|------------------------|
| 1 | Rail Line | 05/12/2016 | 2.0 | -1.5 | 5.9 | 5.9 | 5.5 | 2.7 | 10.6 | 10.6 | 17 | Y | N | N |
| 2 | Rail Line | 05/12/2016 | 0.0 | -0.5 | -2.0 | 0.0 | 3.2 | 0.4 | 1.6 | 1.6 | 2 | Y | N | N |
| 3 | Rail Line | 05/12/2016 | 4.0 | 3.5 | 13.8 | 13.8 | 1.8 | -1.0 | -3.9 | 0.0 | 14 | Y | Y | N |
| 4 | Rail Line | 05/12/2016 | 1.0 | 0.5 | 2.0 | 2.0 | 3.9 | 1.1 | 4.3 | 4.3 | 6 | Y | N | N |
| 5 | Rail Line | 05/12/2016 | 3.0 | 2.5 | 9.9 | 9.9 | 7.2 | 4.4 | 17.3 | 17.3 | 27 | Y | N | N |
| 6 | Rail Line | 05/12/2016 | 0.0 | -0.5 | -2.0 | 0.0 | 6.2 | 3.4 | 13.4 | 13.4 | 13 | Y | N | N |
| 7 | Rail Line | 05/12/2016 | 0.0 | -0.5 | -2.0 | 0.0 | 3.2 | 0.4 | 1.6 | 1.6 | 2 | Y | N | N |
| 8 | Rail Line | 05/12/2016 | 2.1 | 1.6 | 6.3 | 6.3 | 1.5 | -1.3 | -5.1 | 0.0 | 6 | Y | N | N |
| 9 | Rail Line | 05/12/2016 | 0.0 | -0.5 | -2.0 | 0.0 | 4.2 | 1.4 | 5.5 | 5.5 | 6 | Y | N | N |
| 10 | Rail Line | 05/12/2016 | 0.0 | -0.5 | -2.0 | 0.0 | 5.2 | 2.4 | 9.4 | 9.4 | 9 | Y | N | N |
| 11 | Rail Line | 05/12/2016 | 1.0 | 0.5 | 2.0 | 2.0 | 3.9 | 1.1 | 4.3 | 4.3 | 6 | Y | N | N |

Min 2
Max 27
Mean 10
Median 6
StDev 7.5
DCGL = 18,925 dpm/100cm²

Removable Activity (dpm/100cm²) = (gcpm-bkg) / ε

Area "swiped" = 100 cm²

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

| Sign Test | | | | | |
|---|-----------|------------------------|--|---|-----------------------------------|
| SAMPLE ID | SAMPLE ID | Gross TSC Step 8.5.4.a | Gross TSC / Adj. Gross DCGL (W _s) Step 8.5.4.b | Difference (1-W _s) Step 8.5.4.d | Corrected Difference Step 8.5.4.e |
| B04-17-01-S-F-S-00 | Rail Line | 513 | 0.027 | 0.973 | 0.973 |
| B04-17-02-S-F-S-00 | Rail Line | 1330 | 0.070 | 0.930 | 0.930 |
| B04-17-03-S-F-S-00 | Rail Line | 536 | 0.028 | 0.972 | 0.972 |
| B04-17-04-S-F-S-00 | Rail Line | 0 | 0.000 | 1.000 | 1.000 |
| B04-17-05-S-F-S-00 | Rail Line | 0 | 0.000 | 1.000 | 1.000 |
| B04-17-06-S-F-S-00 | Rail Line | 77 | 0.004 | 0.996 | 0.996 |
| B04-17-07-S-F-S-00 | Rail Line | 65 | 0.003 | 0.997 | 0.997 |
| B04-17-08-S-F-S-00 | Rail Line | 0 | 0.000 | 1.000 | 1.000 |
| B04-17-09-S-F-S-00 | Rail Line | 8 | 0.000 | 1.000 | 1.000 |
| B04-17-10-S-F-S-00 | Rail Line | 330 | 0.017 | 0.983 | 0.983 |
| B04-17-11-S-F-S-00 | Rail Line | 364 | 0.019 | 0.981 | 0.981 |
| Number of Positive Differences (S+) | | | | | 11 |
| Sign Test Critical Value (MARSSIM Table I-3) | | | | | 8 |

$\alpha = 0.05$

| MARSSIM Table I-3 Critical Values for the Sign Test Statistic S+ | | MARSSIM Table I-3 Critical Values for the Sign Test Statistic S+ | |
|--|--------------|---|------|
| N | Alpha = 0.05 | N | 0.05 |
| 4 | 4 | 28 | 18 |
| 5 | 4 | 29 | 19 |
| 6 | 5 | 30 | 19 |
| 7 | 6 | 31 | 20 |
| 8 | 6 | 32 | 21 |
| 9 | 7 | 33 | 21 |
| 10 | 8 | 34 | 22 |
| 11 | 8 | 35 | 22 |
| 12 | 9 | 36 | 23 |
| 13 | 9 | 37 | 23 |
| 14 | 10 | 38 | 24 |
| 15 | 11 | 39 | 25 |
| 16 | 11 | 40 | 25 |
| 17 | 12 | 41 | 26 |
| 18 | 12 | 42 | 26 |
| 19 | 13 | 43 | 27 |
| 20 | 14 | 44 | 27 |
| 21 | 14 | 45 | 28 |
| 22 | 15 | 46 | 29 |
| 23 | 15 | 47 | 29 |
| 24 | 16 | 48 | 30 |
| 25 | 17 | 49 | 30 |
| 26 | 17 | 50 | 31 |
| 27 | 18 | | |

If every measurement in the systematic sample population is \leq the DCGL, a statistical test is not required.

TEST: PASS