

# Phase II Final Status Survey Report Mallinckrodt Columbium-Tantalum Plant

St. Louis, Missouri

## Chapter 19


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**Project No. 137131****Revision 0**

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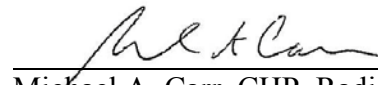
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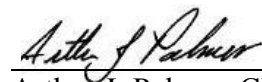
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**ABBREVIATIONS AND ACRONYMS**

%	percent
$\sigma$	sigma; standard deviation
AECOM	AECOM Technical Services
bgs	below grade surface
C-T	columbium-tantalum
CFR	Code of Federal Regulations
cm	centimeter
cpm	counts per minute
DCGL	derived concentration guideline level
DP	decommissioning plan
DQO	data quality objectives
EMC	elevated measurement comparison
EnergySolutions, LLC	EnergySolutions
FSS	Final Status Survey
FSSR	Final Status Survey Report
ft	feet
GWS	gamma walk-over survey
m	meters
m <sup>2</sup>	square meters
MARSSIM	Multi-Agency Radiation and Site Investigation Manual (NUREG-1575)
MDC	minimum detectable concentration
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
pCi/g	picoCuries per gram
Ra	radium
SOF	sum of fractions
Th	thorium
U	uranium
Unc.	uncertainty
WRS	Wilcoxon Rank Sum

## 19.0 RESULTS SUMMARY FOR PLANT 5 SUBSURFACE SU13

This chapter of the Final Status Survey Report (FSSR) presents the results of the final status survey (FSS) and data assessment for Plant 5 subsurface survey unit SU13 in accordance with the Columbium-Tantalum (C-T) Phase II Decommissioning Plan (DP) Section 14.5. The FSS for this Class 2 survey unit was completed by EnergySolutions, LLC (EnergySolutions) in December of 2012. The SU13 data assessment was performed based on the assumptions, methods, and performance criteria established to satisfy the data quality objectives (DQOs) in accordance with the C-T Phase II DP Section 14.4.3.8. The summary statistics provide numerical values for measures of central tendency (i.e., mean, median), variation (i.e., standard deviation), and spread (i.e., minimum, maximum). Data evaluation and statistical analyses were performed and a separate decision was made for each survey unit of the C-T Plant as to its suitability for release for unrestricted use based upon the industrial use scenario release criterion as established in C-T Phase II DP Chapter 5.

### 19.1 OVERVIEW

SU13 is a Class 2 survey unit in the southwest portion of C-T Plant 5. The survey unit is approximately 2,170 square meters (m<sup>2</sup>) in size, which is less than the size limit of 10,000 m<sup>2</sup> for Class 2 survey units for subsurface material (per C-T Phase II DP, Table 14-4). Class 2 was the appropriate classification because the survey unit contained residual radioactivity that did not exceed the derived concentration guideline value (DCGL<sub>W</sub>). Figure 19-1 shows the location of SU13 within the Plant 5 area while Figure 19-2 depicts the features within the survey unit, the extent of excavation and the locations and directions of photographs taken as presented in the following subsections to facilitate the text.

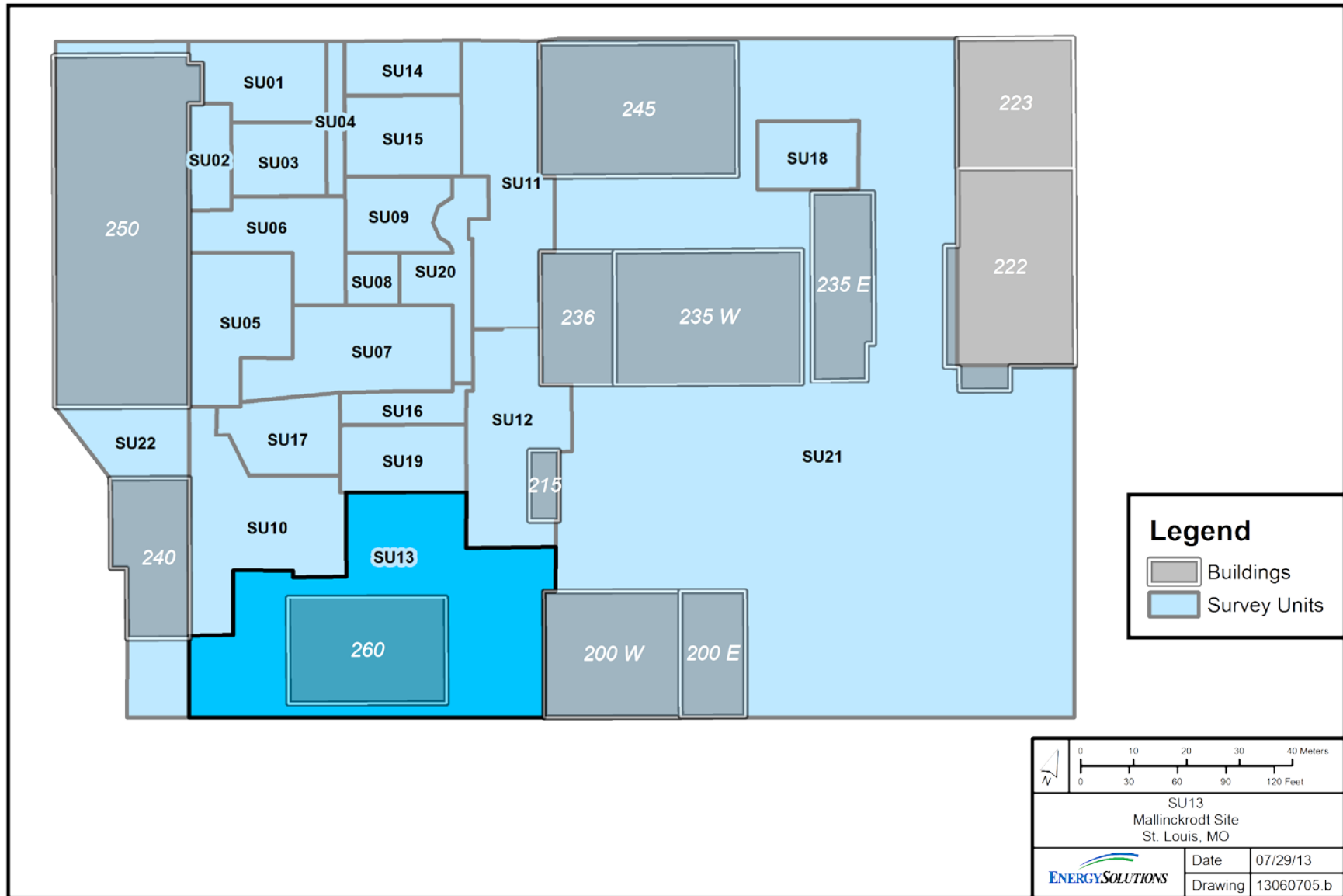


Figure 19-1 Location of SU13 in C-T Plant 5

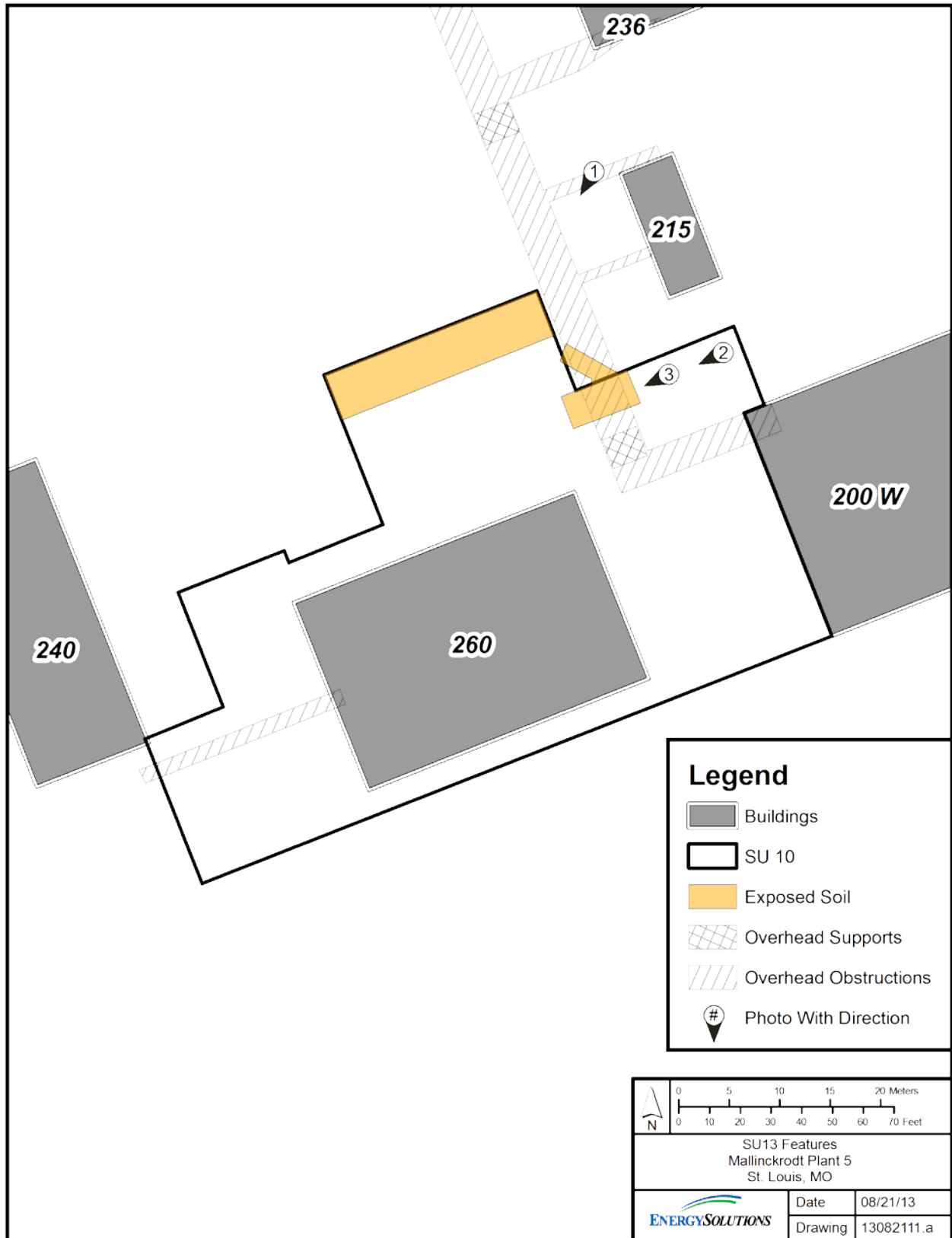


Figure 19-2 SU13 Feature Diagram

### 19.1.1 General Excavation

A portion of SU13 was partially excavated during the remediation of SU19 as depicted in Figure 19-2. This included the removal of the concrete cap and a former building foundation from the northern end of the survey unit as shown in Figure 19-3 (photograph 1). Photograph 1 was taken from the northwest corner of Building 215 with Buildings 260 and 240 in the background. This area was excavated to a depth of approximately 2 to 3 feet (ft) below grade surface (bgs) as part of the concrete removal and to support potential sloping to facilitate the SU19 remediation as needed.

In addition, pavement and concrete with surface cracks as shown in Figure 19-4 and Figure 19-5 (photographs 2 and 3) located on the north side of Building 260 were also removed along with some surface soils due to elevated surface scans. No other excavation was performed within the survey unit.

### 19.1.2 Systematic Sample Location 5

During FSS and core boring of SU13 in December of 2012, a small area of subsurface contamination was identified directly adjacent to SU10 near the northwest corner of Building 260. Contamination was identified at systematic sample location 5 between 0-2 meters (m) bgs which was bounded by additional core boring samples collected to the east and west. This small area was subsequently segregated from SU13 and included part of SU10 and addressed in Chapter 16.



Figure 19-3 Photograph (1) of SU13 at Time of FSS





**Figure 19-4 Photograph (2) SU13 North Side Building 260**



**Figure 19-5 Photograph (3) SU13 Surface Cracks Removed**

19.2 CHARACTERIZATION DATA SUMMARY

C-T Phase II DP Tables 4-7, 4-11, 4-15, and 4-16 provided characterization borehole results. Of the locations provided in the tables, 14 were collected within the extent of SU13. Table 19-1 provides the data for the locations.

Table 19-1 Historic Characterization Borehole Results

Location ID	Sample Depth (ft)	Activity Concentration (pCi/g) <sup>a</sup>			SOF <sup>b</sup>	
		<sup>232</sup> Th	<sup>226</sup> Ra	<sup>238</sup> U	Gross	Net <sup>c</sup>
BH-049	0.6 - 0.9	1.10	4.80	4.90	0.22	0.08
	3 - 3.4	1.20	4.80	6.80	0.22	0.08
	4 - 4.3	1.20	1.20	1.10	0.09	0.00
BH-084	0.5 - 1.5	0.96	2.10	2.85	0.12	0.00
	3 - 4.5	1.05	1.14	2.58	0.09	0.00
	6 - 7.5	1.04	1.41	0.82	0.09	0.00
BH-087	1 - 1.5	1.46	4.46	31.60	0.26	0.11
	3 - 4.5	1.32	2.46	27.40	0.18	0.03
	6 - 7.5	0.64	0.05	7.60	0.04	0.00
	9 - 10.5	1.12	1.03	7.50	0.09	0.00
	12 - 13.5	1.04	0.75	7.00	0.08	0.00
BH-105	0 - 2	0.77	0.53	3.92	0.06	0.00
	2 - 4	0.34	0.20	0.30	0.02	0.00
	4 - 5.5	0.36	0.10	0.41	0.02	0.00
BH-106	0 - 2	1.04	0.63	11.85	0.08	0.01
	2 - 4	1.00	0.88	12.34	0.09	0.01
	4 - 6	0.35	0.18	0.71	0.02	0.00
BH-107	0 - 2	0.75	0.39	2.35	0.05	0.00
	2 - 4	0.44	0.37	2.41	0.03	0.00
	4 - 6	0.79	0.58	1.81	0.06	0.00
BH-108	0 - 2	0.70	0.43	2.15	0.05	0.00
	2 - 4	0.74	0.42	3.30	0.05	0.00
	4 - 6	0.53	0.34	1.60	0.04	0.00
	6 - 8	0.47	0.55	2.37	0.04	0.00
	8 - 10	0.48	0.26	1.61	0.03	0.00
BH-109	0 - 2	0.97	0.19	5.27	0.05	0.00
	2 - 4	0.88	0.33	3.74	0.05	0.00
	4 - 6	0.97	0.26	4.38	0.06	0.00
	6 - 8	0.82	0.17	3.38	0.04	0.00
	8 - 10	0.48	0.36	3.01	0.04	0.00
BH-110	0 - 2	1.05	0.65	6.50	0.08	0.00
	2 - 4	0.99	1.02	3.06	0.08	0.00
	4 - 6	0.89	0.57	5.04	0.06	0.00
	6 - 8	0.36	0.88	6.74	0.05	0.00
BH-111	0 - 2	1.05	0.81	7.68	0.08	0.00
	2 - 4	1.65	1.39	10.53	0.13	0.02
	4 - 6	0.86	0.44	3.43	0.06	0.00
BH-121 <sup>d</sup>	0 - 1	1.24	82.50	4.07	2.86	2.72
JA-19	0 - 0.5	5.08	1.63	4.94	0.27	0.16
JA-20	0 - 0.5	2.94	0.43	1.76	0.14	0.07

**Table 19-1 Historic Characterization Borehole Results (continued)**

Location ID	Sample Depth (ft)	Activity Concentration (pCi/g) <sup>a</sup>			SOF <sup>b</sup>	
		<sup>232</sup> Th	<sup>226</sup> Ra	<sup>238</sup> U	Gross	Net <sup>c</sup>
JA-25	0 - 3	<i>0.10</i>	2.10	3.40	0.08	0.00

<sup>a</sup> Italicized results indicate <MDC.

<sup>b</sup> **Bolded red** SOF values indicate a result >1.

<sup>c</sup> Calculated as discussed in Section 19.3.2.

<sup>d</sup> Mallinckrodt records indicate that the soil associated with this sample result was excavated and disposed during the construction of Building 260.

AECOM Technical Services (AECOM) also collected numerous supplemental characterization core boring samples within the extent of SU13. Table 19-2 provides those results. During the sampling effort, AECOM noted that the clay layer depth ranged between 12 and 15.9 ft bgs

**Table 19-2 AECOM Supplemental Characterization Borehole Results**

Location ID	Sample ID	Sample Depth (m)	Activity Concentration (pCi/g) <sup>a</sup>			Sample SOF <sup>b</sup>		Column SOF <sup>b, c</sup>	
			<sup>232</sup> Th	<sup>226</sup> Ra	<sup>238</sup> U	Gross	Net <sup>d</sup>	Gross	Net <sup>d</sup>
A11-2	4542	0 - 1	0.57	2.60	8.02	0.12	0.01	0.12	0.01
	4543	1 - 2	0.98	2.51	5.49	0.13	0.00	0.13	0.01
	4544	2 - 3	1.11	1.21	2.63	0.09	0.00	0.12	0.00
	4545	3 - 4	0.94	0.44	1.21	0.06	0.00	0.10	0.00
Clay layer reached at 11.5 ft bgs									
B11-1	4527	0 - 1	1.18	1.82	6.02	0.12	0.00	0.12	0.00
	4528	1 - 2	1.15	2.01	2.83	0.12	0.00	0.12	0.00
	4529	2 - 3	1.03	2.02	3.26	0.12	0.00	0.12	0.00
	4530	3 - 4	0.76	1.68	2.12	0.09	0.00	0.11	0.00
Clay layer reached at 12.25 ft bgs									
B11-2	4531	0 - 1	0.62	1.87	2.76	0.09	0.00	0.09	0.00
	4532	1 - 2	0.40	1.14	1.12	0.06	0.00	0.08	0.00
Refusal (concrete) at 5 ft bgs									
B11-3	4538	0 - 1	0.82	2.47	3.16	0.12	0.00	0.12	0.00
	4539	1 - 2	1.60	22.40	11.16	<b>0.84</b>	<b>0.70</b>	0.48	0.34
	4540	2 - 3	1.00	1.13	2.51	0.08	0.00	0.35	0.21
	4541	3 - 4	0.95	1.02	0.85	0.08	0.00	0.28	0.14
Clay layer reached at 12 ft bgs									
D9-1	4622	0 - 1	0.75	1.69	2.30	0.09	0.00	0.09	0.00
	4623	1 - 2	1.03	1.46	1.98	0.10	0.00	0.09	0.00
	4624	2 - 3	0.79	3.26	2.82	0.15	0.03	0.11	0.01
	4625	3 - 4	2.12	9.03	22.91	0.43	0.28	0.19	0.05
	4626	4 - 5	1.18	1.83	1.60	0.11	0.00	0.18	0.04
Clay layer reached at 15 ft bgs									
D9-2	4627	0 - 1	1.70	4.02	12.69	0.23	0.08	0.23	0.08
	4628	1 - 2	1.16	6.13	5.67	0.26	0.13	0.25	0.10
	4629	2 - 3	1.43	3.93	9.22	0.21	0.06	0.23	0.09
	4630	3 - 4	1.07	9.72	15.76	0.40	0.26	0.27	0.13
	4631	4 - 5	1.00	1.24	1.72	0.09	0.00	0.24	0.09
Clay layer reached at 14.5 ft bgs									

Table 19-2 AECOM Supplemental Characterization Borehole Results (continued)

Location ID	Sample ID	Sample Depth (m)	Activity Concentration (pCi/g) <sup>a</sup>			Sample SOF <sup>b</sup>		Column SOF <sup>b, c</sup>	
			<sup>232</sup> Th	<sup>226</sup> Ra	<sup>238</sup> U	Gross	Net <sup>d</sup>	Gross	Net <sup>d</sup>
D10-1	4576	0 - 1	1.11	1.95	3.40	0.12	0.00	0.12	0.00
	4577	1 - 2	0.88	2.46	4.89	0.13	0.00	0.12	0.00
	4578	2 - 3	0.94	2.54	5.35	0.13	0.00	0.13	0.00
	4579	3 - 4	1.32	1.59	22.96	0.14	0.03	0.13	0.01
	4580	4 - 5	0.93	0.74	1.38	0.07	0.00	0.12	0.00
Clay layer reached at 15 ft bgs									
D11-1	4510	0 - 1	1.15	3.77	6.41	0.19	0.05	0.19	0.05
	4511	1 - 2	0.82	4.02	3.84	0.18	0.05	0.18	0.05
	4512	2 - 3	1.34	1.87	3.12	0.12	0.00	0.16	0.02
	4513	3 - 4	1.05	2.37	4.67	0.13	0.00	0.15	0.02
Clay layer reached at 12 ft bgs									
D11-2	4514	0 - 1	0.83	4.79	16.12	0.22	0.09	0.22	0.09
	4515	1 - 2	0.00	1.62	1.61	0.06	0.00	0.14	0.03
	4516	2 - 3	1.05	3.04	5.95	0.16	0.02	0.14	0.03
	4517	3 - 4	0.97	1.20	1.48	0.08	0.00	0.13	0.01
Clay layer reached at 12 ft bgs									
E9-1	4612	0 - 1	0.56	2.39	1.85	0.11	0.00	0.11	0.00
	4613	1 - 2	1.05	1.79	2.05	0.11	0.00	0.11	0.00
	4614	2 - 3	0.43	2.31	3.39	0.10	0.00	0.11	0.00
	4615	3 - 4	1.54	3.82	20.00	0.22	0.08	0.13	0.01
	4616	4 - 5	1.08	6.33	14.65	0.28	0.14	0.16	0.03
Clay layer reached at 15.9 ft bgs									
E9-2	4617	0 - 1	1.10	2.60	6.91	0.14	0.01	0.14	0.01
	4618	1 - 2	1.12	2.14	3.02	0.12	0.00	0.13	0.00
	4619	2 - 3	1.02	3.78	6.72	0.18	0.05	0.15	0.01
	4620	3 - 4	1.45	7.31	22.94	0.34	0.20	0.20	0.06
	4621	4 - 5	0.95	2.12	1.14	0.11	0.00	0.18	0.04
Clay layer reached at 15.9 ft bgs									
E10-1	4586	0 - 1	0.96	4.19	3.22	0.19	0.06	0.19	0.06
	4587	1 - 2	0.58	1.54	1.30	0.08	0.00	0.13	0.01
	4588	2 - 3	0.56	0.82	1.14	0.05	0.00	0.11	0.00
	4589	3 - 4	1.09	3.56	6.41	0.18	0.04	0.12	0.00
	4590	4 - 5	0.95	1.89	6.44	0.11	0.00	0.12	0.00
	4591	5 - 6	1.28	1.75	1.71	0.12	0.00	0.12	0.00
Clay layer reached at 14 ft bgs									
E10-2	0 - 1	0 - 1	0.96	1.85	2.09	0.11	0.00	0.11	0.00
	1 - 2	1 - 2	0.76	1.49	1.65	0.08	0.00	0.10	0.00
	2 - 3	2 - 3	0.91	4.49	4.19	0.20	0.07	0.13	0.00
	3 - 4	3 - 4	0.96	4.20	16.00	0.21	0.07	0.15	0.02
	4 - 5	4 - 5	0.99	1.21	1.81	0.09	0.00	0.14	0.01
Clay layer reached at 15 ft bgs									
E11-1	4502	0 - 1	0.91	2.40	1.53	0.12	0.00	0.12	0.00
	4503	1 - 2	0.33	2.42	2.47	0.10	0.00	0.11	0.00
	4504	2 - 3	0.77	1.63	1.52	0.09	0.00	0.10	0.00
Refusal (slag) at 7.5 ft bgs									

Table 19-2 AECOM Supplemental Characterization Borehole Results (continued)

Location ID	Sample ID	Sample Depth (m)	Activity Concentration (pCi/g) <sup>a</sup>			Sample SOF <sup>b</sup>		Column SOF <sup>b, c</sup>	
			<sup>232</sup> Th	<sup>226</sup> Ra	<sup>238</sup> U	Gross	Net <sup>d</sup>	Gross	Net <sup>d</sup>
E11-2	4505	0 - 1	1.09	6.95	3.12	0.29	0.15	0.29	0.15
	4506	1 - 2	0.37	2.89	2.07	0.12	0.01	0.20	0.08
	4507	2 - 3	1.11	5.18	4.46	0.23	0.09	0.21	0.09
	4508	3 - 4	1.09	1.02	1.57	0.08	0.00	0.18	0.05
	4509	4 - 5	0.99	1.02	1.41	0.08	0.00	0.16	0.03
Clay layer reached at 15.9 ft bgs									
F9-1	4607	0 - 1	1.01	2.37	3.27	0.13	0.00	0.13	0.00
	4608	1 - 2	0.56	1.43	1.36	0.07	0.00	0.10	0.00
	4609	2 - 3	0.98	3.67	4.59	0.17	0.04	0.12	0.00
	4610	3 - 4	0.94	2.47	2.85	0.13	0.00	0.13	0.00
	4611	4 - 5	1.11	1.00	1.11	0.08	0.00	0.12	0.00
Clay layer reached at 15.9 ft bgs									
F10-1	4592	0 - 1	1.00	4.62	3.18	0.20	0.07	0.20	0.07
	4593	1 - 2	0.73	2.20	2.22	0.11	0.00	0.16	0.03
	4594	2 - 3	0.97	1.54	2.38	0.10	0.00	0.14	0.01
	4595	3 - 4	0.37	0.99	1.84	0.05	0.00	0.11	0.00
Refusal (quartz) at 13 ft bgs									
F11-1	4546	0 - 1	0.85	2.63	1.87	0.13	0.00	0.13	0.00
	4547	1 - 2	1.97	5.61	10.35	0.29	0.14	0.21	0.06
	4548	2 - 3	0.35	1.05	2.22	0.05	0.00	0.16	0.02
	4549	3 - 4	1.03	1.18	2.28	0.09	0.00	0.14	0.00
	4550	4 - 5	1.14	1.26	2.38	0.09	0.00	0.13	0.00
Clay layer not reached									
F11-2	4552	0 - 1	1.28	3.26	4.52	0.17	0.03	0.17	0.03
	4553	1 - 2	0.71	2.01	1.92	0.10	0.00	0.14	0.00
	4554	2 - 2.8	0.86	1.93	2.85	0.11	0.00	-- <sup>e</sup>	
	4555	2.8 - 3.6	1.88	4.59	9.09	0.25	0.10		
	4556	3.6 - 4.4	4.61	10.52	24.75	0.58	0.44		
	4557	4.4 - 5	0.16	5.02	4.84	0.18	0.09		
Clay layer reached at 12 ft bgs									
F11-3	4558	0 - 1	0.91	2.10	1.20	0.11	0.00	0.11	0.00
	4559	1 - 2	0.72	1.12	1.33	0.07	0.00	0.09	0.00
	4560	2 - 3	0.63	2.05	2.75	0.10	0.00	0.09	0.00
	4561	3 - 4	3.70	3.16	9.50	0.28	0.13	0.14	0.01
	4562	4 - 5	4.13	5.13	14.61	0.37	0.22	0.18	0.04
Clay layer reached at 15 ft bgs									
G11-1	Refusal (concrete) at 2.5 ft bgs								

Table 19-2 AECOM Supplemental Characterization Borehole Results (continued)

Location ID	Sample ID	Sample Depth (m)	Activity Concentration (pCi/g) <sup>a</sup>			Sample SOF <sup>b</sup>		Column SOF <sup>b, c</sup>	
			<sup>232</sup> Th	<sup>226</sup> Ra	<sup>238</sup> U	Gross	Net <sup>d</sup>	Gross	Net <sup>d</sup>
SB-017	4859	0 - 1	1.03	2.21	4.81	0.12	0.00	0.12	0.00
	4860	1 - 2	1.04	1.33	2.82	0.09	0.00	0.11	0.00
	4864	2 - 3	0.80	1.48	1.72	0.09	0.00	0.10	0.00
	4865	3 - 4	4.83	7.61	27.81	0.50	0.35	0.20	0.06
	4866	4 - 5	3.03	7.79	17.44	0.42	0.27	0.24	0.10
Clay layer reached at 14 ft bgs									

<sup>a</sup> Italicized results indicate <MDC.

<sup>b</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1.

<sup>c</sup> Calculated per Section 14.4.3.7 of C-T Phase II DP.

<sup>d</sup> Calculated as discussed in Section 19.3.2.

<sup>e</sup> Column average not calculated because collected data were not in 1-m increments.

In accordance with Table 14-5 of the C-T Phase II DP, the Class 2 subsurface investigation level is the DCGL<sub>w</sub> (1 SOF [sum of fractions]) plus the mean of background (0.15 SOF) plus two standard deviations of background (2 × 0.09 SOF = 0.18 SOF), using data from Tables 4-17 and B-1. This evaluates to a gross SOF of 1.33. All characterization borehole samples, with the exception of historical BH-121, were below this investigation level; therefore, no excavation was anticipated.

### 19.3 DATA COLLECTION

Data collection was performed based on the assumptions, methods, and performance criteria established to satisfy the DQOs in accordance with the C-T Phase II DP, Sections 14.4.1 and 14.4.3. Details regarding FSS design and quality assurance and quality control applicable to all survey units were discussed in Chapters 4 and 5, respectively, of this FSSR. FSS data as collected for SU13 is summarized as described below.

#### 19.3.1 Gamma Scans

A gamma walk-over survey (GWS) was performed over accessible areas of the survey unit in order to locate radiation anomalies that might indicate areas with elevated residual radioactivity where further data collection (i.e., biased soil sampling) was warranted. Areas of exposed soil were fully scanned while the paved areas were scanned to the maximum extent practical.

Figure 19-6 provides the GWS scan results and survey coverage. The recorded survey results ranged from 3,180 to 15,060 counts per minute (cpm) with a mean of 5,552 cpm and a median of 5,460 cpm for asphalt. The recorded survey results over exposed soil ranged from 4,380 to 15,060 cpm with a mean of 10,107 cpm and a median of 10,260 cpm. Elevated readings were identified over the asphalt north of Building 260 along some surface cracks as well as an area within the security fence at the northeast corner. The pavement and concrete north of Building 260 containing these surface cracks were removed along with some surface soils while the area inside the fence was investigated via biased borehole sampling. Additional elevated readings near the asphalt perimeter were due to the proximity to soil.

### 19.3.2 Soil Sampling

Soil samples to be used for the statistical testing were collected at a frequency and at representative locations throughout SU13 such that a statistically sound conclusion regarding the radiological condition of the survey unit could be developed. Biased samples were also collected at locations of elevated residual activity as identified by GWS. Samples throughout SU13 consisted of 1-m composite samples from boreholes with the exception of the 3 biased samples collected from surface soils following the removal of the surface cracks in the asphalt and some of the exposed soil.

Borehole samples were collected in 1-m intervals to the clay layer which was approximately 4 to 5 m bgs while surface samples consisted of the top 30-centimeter (cm) of soil. The FSS soil sampling locations are provided on Figure 19-6. A total of 66 soil samples were collected throughout SU13: 59 1-m composites from 13 systematic, 4 1-m composites from 2 biased boreholes, Page 15 and 3 from biased surface locations. Figure 19-7 also shows the locations of all characterization and FSS samples that were collected within SU13.

Systematic sample locations 5 and 10 were segregated from SU13 and included as part of SU10 because of the identification of elevated materials. Contamination was found within the top 2 m as discussed in Section 19.1.2 which was ultimately remediated and the area included in SU10 as a Class 1 areas. Systematic sample location 10 was also included within SU10 due to its proximity to the planned borehole location for systematic sample 15 and due to subsurface activity that was identified which was consistent with materials found within SU10.

All FSS soil samples were analyzed on site via gamma spectroscopy analysis. Any remaining sieved material from each sample was analyzed separately to verify residual radioactivity was consistent with sample results. The radiological screening process did not identify any significant levels of radioactivity in the sieved materials removed from samples.

The C-T Phase II DP, Table 4-17, provided mean background activity levels of 1.3, 2.5, and 4.4 picoCuries per gram (pCi/g) for thorium-232 ( $^{232}\text{Th}$ ), radium-226 ( $^{226}\text{Ra}$ ), and uranium-238 ( $^{238}\text{U}$ ), respectively. These values were used to calculate net SOF values—note that when measured activity concentration levels were less than the background mean resulting in a negative value, the net activity concentration was set equal to zero for the net SOF calculation.

Table 19-3 and Table 19-4 provide the sample results for the 59 samples from 13 systematic borehole locations and the 4 samples from 2 biased borehole locations, respectively. Table 19-5 provides the sample results for the 3 biased surface samples from under the surface cracks within the asphalt.

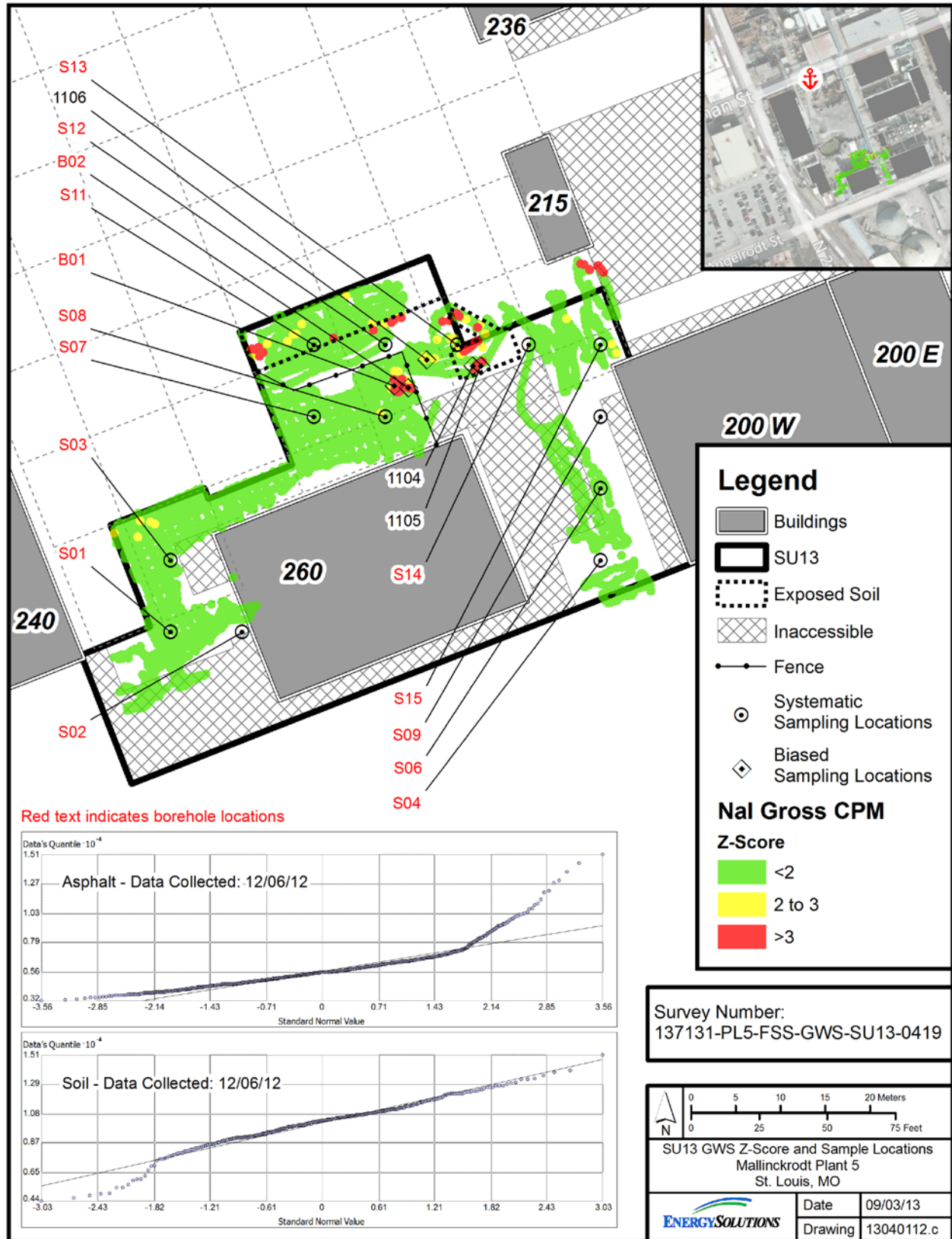


Figure 19-6 GWS and Biased Soil Sampling Locations



Table 19-3 Gamma Spectroscopy Systematic Borehole Sample Analytical Results

Sample Location	Sample ID	Sample Depth (m) <sup>a</sup>	On-Site Results											Off-Site Results <sup>b</sup>										Column SOF <sup>c,d</sup>			
			Activity Concentration (pCi/g)									Sample SOF <sup>c</sup>		Activity Concentration (pCi/g)									Sample SOF <sup>c</sup>				
			<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U					<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U							
			Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>e</sup>	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>e</sup>	Gross	Net <sup>e</sup>	
S01	0611	0 - 1	1.18	0.26	0.19	6.56	1.70	1.19	8.37	0.98	0.82	0.28	0.14	Samples Not Sent to Off-Site Laboratory (Gross SOF < 0.5)										0.28	0.14		
	0610	1 - 2	0.81	0.21	0.09	1.80	0.81	0.59	2.19	0.46	0.45	0.10	0.00												0.19	0.06	
	0609	2 - 3	1.18	0.28	0.15	1.62	0.95	0.71	1.81	0.51	0.39	0.11	0.00													0.16	0.03
S02	0612	0 - 1	0.90	0.23	0.05	1.29	0.85	0.64	2.08	0.51	0.45	0.08	0.00													0.08	0.00
	0613	1 - 2	0.79	0.16	0.08	2.09	0.91	0.66	1.79	0.41	0.36	0.11	0.00													0.10	0.00
	0614	2 - 3	1.41	0.22	0.03	2.11	0.86	0.61	2.73	0.54	0.53	0.13	0.00													0.11	0.00
S03	0615	3 - 4	1.59	0.28	0.09	1.27	1.02	0.78	2.64	0.56	0.55	0.11	0.01													0.11	0.00
	0604	0 - 1	0.89	0.22	0.14	3.17	1.15	0.82	3.81	0.64	0.63	0.15	0.02													0.15	0.02
	0605	1 - 2	1.15	0.27	0.10	4.29	1.26	0.88	6.13	0.77	0.66	0.20	0.06													0.18	0.04
S04	0606	2 - 3	1.30	0.29	0.11	2.65	1.00	0.69	3.57	0.89	0.52	0.15	0.01													0.17	0.03
	0518	0 - 1	1.86	0.41	0.11	3.72	1.37	0.98	4.00	0.80	0.78	0.21	0.06													0.21	0.06
	0519	1 - 2	0.67	0.20	0.09	1.82	0.93	0.68	2.15	0.46	0.42	0.09	0.00													0.15	0.01
	0520	2 - 3	0.75	0.21	0.08	2.03	1.06	0.78	3.25	0.58	0.52	0.10	0.00													0.14	0.00
	0521	3 - 4	1.60	0.26	0.10	3.99	1.30	0.92	4.02	0.73	0.64	0.21	0.06													0.15	0.01
S06	0522	4 - 5	1.47	0.38	0.11	1.75	0.82	0.59	1.35	0.48	0.48	0.12	0.01													0.15	0.01
	0523	0 - 1	1.92	0.43	0.19	4.57	1.70	1.25	6.90	0.82	0.68	0.25	0.10													0.25	0.10
	0524	1 - 2	1.46	0.51	0.19	4.03	1.25	0.84	2.89	0.60	0.63	0.20	0.06													0.22	0.08
	0525	2 - 3	1.06	0.26	0.12	3.74	1.34	0.94	4.14	0.72	0.65	0.18	0.04													0.21	0.06
	0526	3 - 4	3.38	0.44	0.22	5.58	2.09	1.58	12.14	1.71	0.87	0.35	0.20													0.24	0.10
S07	0527	4 - 5	1.53	0.30	0.16	2.70	1.53	1.17	7.14	0.84	0.67	0.17	0.02													0.23	0.08
	0616	0 - 1	1.26	0.27	0.12	6.62	1.57	1.08	7.48	1.43	0.79	0.29	0.14													0.29	0.14
	0617	1 - 2	0.83	0.21	0.10	3.62	1.20	0.84	4.84	0.65	0.53	0.16	0.04													0.23	0.09
	0618	2 - 3	1.39	0.26	0.12	3.51	1.15	0.81	3.18	0.72	0.62	0.18	0.04													0.21	0.07
	0619	3 - 4	1.47	0.30	0.13	6.30	1.79	1.28	10.35	0.98	0.71	0.29	0.14													0.23	0.09
S08	0620	4 - 5	1.45	0.30	0.15	5.28	1.63	1.17	9.90	1.03	0.81	0.25	0.11													0.24	0.09
	0543	0 - 1	1.61	0.37	0.24	16.90	2.39	1.35	4.49	1.01	1.07	0.65	0.50													0.65	0.50
	0544	1 - 2	1.66	0.40	0.12	8.35	1.74	1.14	3.14	0.85	0.76	0.36	0.21													0.50	0.36
	0545	2 - 3	0.93	0.23	0.07	4.22	1.26	0.87	3.65	0.68	0.62	0.19	0.06													0.40	0.25
	0546	3 - 4	1.35	0.27	0.09	1.57	0.91	0.67	1.71	0.54	0.45	0.11	0.00												0.33	0.18	
S09	0533	0 - 1	1.03	0.22	0.08	2.34	0.85	0.57	1.74	0.49	0.47	0.13	0.00												0.13	0.00	
	0534	1 - 2	0.46	0.11	0.02	0.88	0.48	0.39	0.64	0.23	0.22	0.05	0.00												0.09	0.00	
	0535	2 - 3	0.91	0.21	0.05	2.86	0.91	0.59	1.89	0.40	0.35	0.14	0.01												0.10	0.00	
	0536	3 - 4	3.05	0.48	0.14	7.76	1.73	1.18	8.64	1.07	0.87	0.40	0.26												0.18	0.04	
	0537	4 - 5	4.63	0.64	0.17	5.49	1.97	1.48	11.19	1.75	0.95	0.40	0.25												0.22	0.08	
S11	0626	0 - 1	1.52	0.32	0.10	2.13	1.00	0.72	1.83	0.60	0.49	0.14	0.01												0.14	0.01	
	0627	1 - 2	0.74	0.21	0.08	1.66	0.62	0.40	0.98	0.33	0.35	0.09	0.00												0.11	0.00	
	0628	2 - 3	0.87	0.16	0.05	1.94	0.88	0.64	2.15	0.46	0.39	0.11	0.00												0.11	0.00	
	0629	3 - 4	1.55	0.33	0.13	4.97	1.71	1.25	7.76	0.89	0.72	0.24	0.10												0.14	0.01	
	0630	4 - 5	2.93	0.42	0.22	12.51	2.18	1.47	9.50	1.60	0.92	0.56	0.42	2.27	0.48	0.35	7.37	0.88	0.22	12.40	3.39	3.57	0.36	0.22	0.19	0.04	
S12	0631	0 - 1	1.14	0.25	0.09	2.46	1.22	0.90	3.21	0.64	0.64	0.14	0.00												0.14	0.00	
	0632	1 - 2	0.61	0.15	0.08	1.85	0.73	0.51	1.34	0.37	0.40	0.09	0.00												0.11	0.00	
	0633	2 - 3	0.66	0.16	0.07	1.17	0.70	0.52	1.37	0.37	0.35	0.07	0.00												0.10	0.00	
	0634	3 - 4	1.00	0.26	0.11	4.18	1.38	1.00	8.34	1.54	0.87	0.20	0.06												0.12	0.00	
	0635	4 - 5	1.23	0.25	0.08	1.91	1.28	0.98	4.74	0.71	0.61	0.12	0.00												0.12	0.00	
S13	0641	0 - 1	1.26	0.30	0.15	2.95	1.42	1.05	3.06	0.66	0.63	0.16	0.02												0.16	0.02	
	0642	1 - 2	1.10	0.33	0.80	3.67	1.27	0.84	2.72	0.79	0.64	0.17	0.04												0.17	0.03	
	0643	2 - 3	1.08	0.26	0.13	3.98	1.37	0.96	4.12	0.76	0.68	0.19	0.05												0.17	0.04	
	0644	3 - 4	1.20	0.29	0.13	4.35	1.55	1.14	5.81	1.09	0.62	0.21	0.06												0.18	0.04	
	0645	4 - 5	1.14	0.27	0.11	3.96	1.29	0.91	4.87	0.75	0.63	0.19	0.05												0.18	0.04	

Table 19-3 Gamma Spectroscopy Systematic Borehole Sample Analytical Results (continued)

Sample Location	Sample ID	Sample Depth (m) <sup>a</sup>	On-Site Results											Off-Site Results <sup>b</sup>										Column SOF <sup>c, d</sup>		
			Activity Concentration (pCi/g)									Sample SOF <sup>c</sup>		Activity Concentration (pCi/g)									Sample SOF <sup>c</sup>			
			<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U					<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U						
			Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>e</sup>	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>e</sup>	Gross	Net <sup>e</sup>
S14	0528	0 - 1	1.19	0.28	0.14	4.14	1.62	1.20	5.34	0.83	0.74	0.20	0.06	Samples Not Sent to Off-Site Laboratory (Gross SOF < 0.5)										0.20	0.06	
	0529	1 - 2	0.33	0.14	0.08	0.97	0.78	0.60	1.73	0.39	0.33	0.05	0.00											0.12	0.00	
	0530	2 - 3	1.38	0.36	0.11	3.04	1.36	0.99	3.11	0.66	0.58	0.17	0.02											0.14	0.01	
	0531	3 - 4	7.85	0.96	0.33	20.82	3.94	2.70	29.76	2.54	1.79	<b>1.08</b>	<b>0.93</b>	5.93	0.85	0.51	11.60	1.39	0.40	30.70	6.33	5.92	<b>0.69</b>	<b>0.54</b>	0.27	0.13
	0532	4 - 5	2.47	0.51	0.16	6.37	1.66	1.18	8.63	1.01	0.85	0.33	0.19	Sample Not Sent to Off-Site Laboratory (Gross SOF < 0.5)										0.29	0.14	
S15	0538	0 - 1	1.38	0.39	0.30	23.15	2.59	1.44	4.16	0.91	0.77	<b>0.85</b>	<b>0.71</b>	Sample was inadvertently disposed prior to off-site analysis										<b>0.85</b>	<b>0.71</b>	
	0539	1 - 2	1.77	0.59	0.47	66.52	5.01	2.36	5.07	2.74	1.46	<b>2.34</b>	<b>2.20</b>	2.25	0.85	1.25	66.10	7.07	0.72	8.78	5.23	6.87	<b>2.35</b>	<b>2.21</b>	<b>1.60</b>	<b>1.46</b>
	0540	2 - 3	0.64	0.21	0.12	4.95	1.03	0.63	1.64	0.43	0.37	0.20	0.08	Samples Not Sent to Off-Site Laboratory (Gross SOF < 0.5)										<b>1.13</b>	<b>0.99</b>	
	0541	3 - 4	4.52	0.53	0.16	10.41	2.09	1.45	14.21	1.96	1.00	<b>0.56</b>	0.42	3.23	0.52	0.26	2.75	0.43	0.22	14.00	2.86	2.77	0.25	0.10	<b>0.91</b>	<b>0.77</b>
	0542	4 - 5	7.26	0.77	0.26	18.64	2.93	1.91	23.36	2.19	1.08	<b>0.97</b>	<b>0.82</b>	6.70	0.94	0.47	5.25	0.76	0.34	32.60	5.74	4.91	<b>0.50</b>	0.36	<b>0.83</b>	<b>0.69</b>

<sup>a</sup> Sampling was stopped when native clay soil was reached or refusal encountered.  
<sup>b</sup> Off-site laboratory results as reported by TestAmerica after sufficient in-growth time to reach <sup>226</sup>Ra progeny equilibrium.  
<sup>c</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1 and **bolded red** SOF values indicate a result >1.  
<sup>d</sup> Calculated per Section 14.4.3.7 of C-T Phase II DP. Calculation of column SOF used on-site results unless off-site results were available.  
<sup>e</sup> Calculated as discussed in Section 19.3.2.

Table 19-4 Gamma Spectroscopy Biased Borehole Sample Analytical Results

Sample Location	Sample ID	Sample Depth (m) <sup>a</sup>	On-Site Results											Off-Site Results										Column SOF <sup>b</sup>	
			Activity Concentration (pCi/g)									Sample SOF		Activity Concentration (pCi/g)									Sample SOF		
			<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U					<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U					
			Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>c</sup>	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>c</sup>	Gross
B01	0912	0 - 1	1.39	0.27	0.70	4.47	1.19	0.77	2.89	0.68	0.69	0.21	0.07	Samples not sent to off-site laboratory (gross SOF < 0.5)										0.21	0.07
	0913	1 - 2	0.93	0.24	0.09	3.80	1.07	0.71	2.09	0.44	0.41	0.17	0.04											0.19	0.06
B02	0914	0 - 1	1.53	0.31	0.12	3.96	1.30	0.90	3.06	0.70	0.68	0.20	0.06											0.20	0.06
	0915	1 - 2	1.14	0.25	0.14	3.94	1.04	0.66	2.79	1.01	0.61	0.19	0.05											0.19	0.05

<sup>a</sup> Sampling was stopped when native clay soil was reached or refusal encountered.  
<sup>b</sup> Calculated per Section 14.4.3.7 of C-T Phase II DP. Calculation of column SOF used on-site results unless off-site results were available.  
<sup>c</sup> Calculated as discussed in Section 19.3.2.

Table 19-5 Gamma Spectroscopy Biased Sample Analytical Results

Sample ID	Depth (ft bgs)	On-Site Results											Off-Site Results <sup>a</sup>										On-Site/Off-Site Gross SOF Ratio	
		Activity Concentration (pCi/g) <sup>b</sup>									SOF <sup>c</sup>		Activity Concentration (pCi/g) <sup>b</sup>									SOF <sup>c</sup>		
		<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U					<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U					
		Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>d</sup>	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross		Net <sup>d</sup>
<b>GWS Biased Samples</b>																								
1104	1	1.26	0.27	0.10	2.56	1.18	0.88	2.70	0.71	0.58	0.14	0.00	Sample not sent to off-site laboratory (gross SOF < 0.5)											
1105	1	1.86	0.51	0.25	20.91	2.55	1.51	4.71	1.21	1.08	<b>0.80</b>	<b>0.65</b>	1.92	0.51	0.50	20.10	2.25	0.37	<i>4.44</i>	1.46	4.57	<b>0.77</b>	<b>0.62</b>	1.03
1106	1	1.85	0.37	0.24	19.55	2.40	1.39	5.57	1.12	1.10	<b>0.75</b>	<b>0.60</b>	2.70	0.83	0.96	19.90	2.41	0.44	4.83	2.10	5.89	<b>0.80</b>	<b>0.65</b>	0.94

<sup>a</sup> Off-site laboratory results as reported by TestAmerica after sufficient in-growth time to reach <sup>226</sup>Ra progeny equilibrium.  
<sup>b</sup> Italicized results indicate <MDC.  
<sup>c</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1.  
<sup>d</sup> Calculated as discussed in Section 19.3.2.

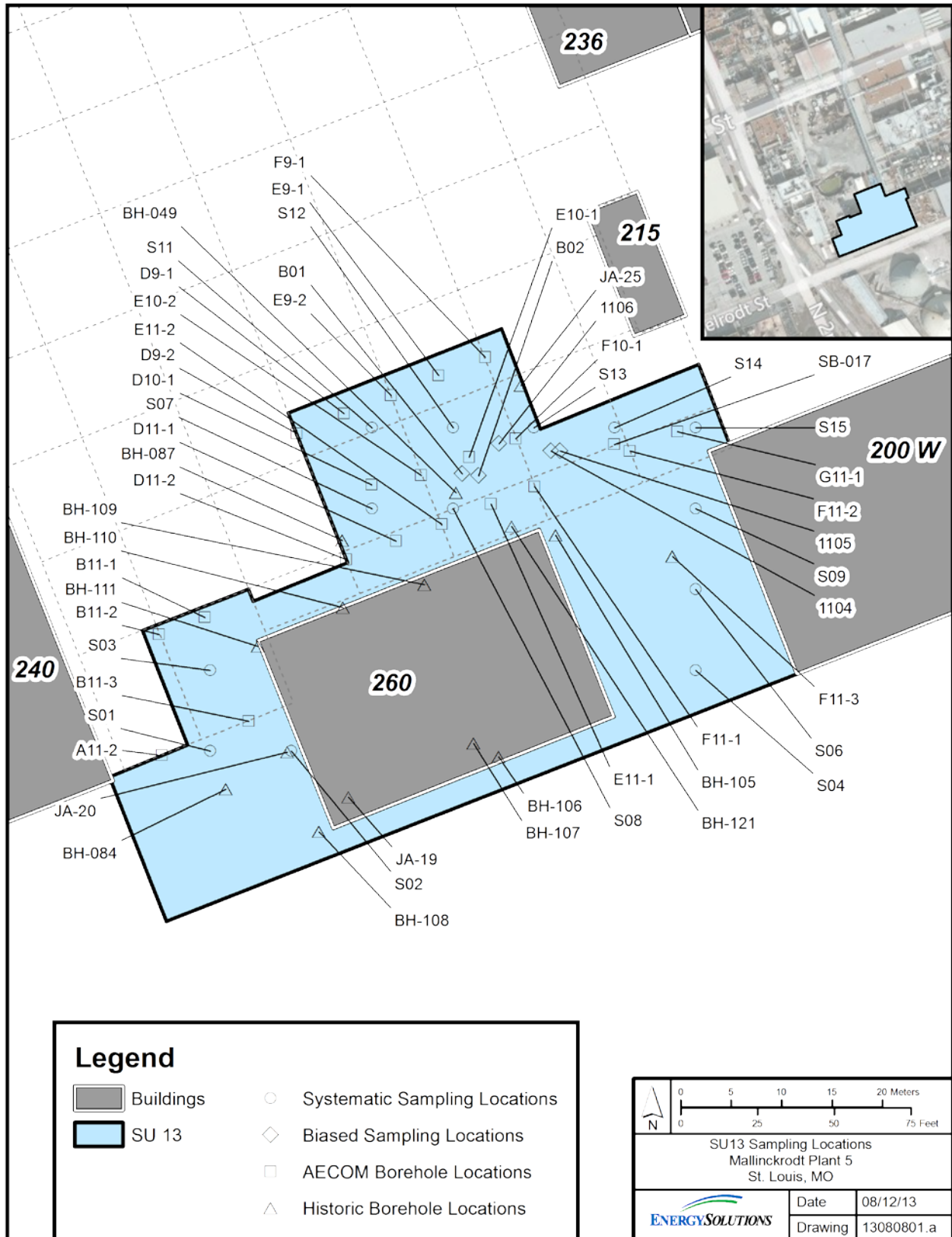


Figure 19-7 Characterization and FSS Sampling Locations

19.4 DATA ANALYSIS – SUBSURFACE MATERIAL

Data analysis of the subsurface material was performed based on the assumptions, methods, and performance criteria established to satisfy the DQOs in accordance with the C-T Phase II DP, Sections 14.4.1 and 14.4.3. Column average gross SOF results were used in the data assessment. Per Page 14-19 of the C-T Phase II DP, column averages were calculated over 1-meter increments (averaged 0 to 1 m, 0 to 2 m, etc.) for the set of samples collected. Table 19-6 provides the calculated borehole column average gross SOF results. Table 19-7 provides the calculated borehole column average net SOF results.

Table 19-6 Systematic Borehole Column Average Gross SOF Results

Sample Location	Core Depth Interval (m)				
	0-1	0-2	0-3	0-4	0-5
	Combined Results for Column Average Gross SOF <sup>a, b</sup>				
S01	0.28	0.19	0.16	--	--
S02	0.08	0.10	0.11	0.11	--
S03	0.15	0.18	0.17	--	--
S04	0.21	0.15	0.14	0.15	0.15
S06	0.25	0.22	0.21	0.24	0.23
S07	0.29	0.23	0.21	0.23	0.24
S08	<b>0.65</b>	<b>0.50</b>	0.40	0.33	--
S09	0.13	0.09	0.10	0.18	0.22
S11	0.14	0.11	0.11	0.14	0.19
S12	0.14	0.11	0.10	0.12	0.12
S13	0.16	0.17	0.17	0.18	0.18
S14	0.20	0.12	0.14	0.27	0.29
S15	<b>0.85</b>	<b>1.60</b>	<b>1.13</b>	<b>0.91</b>	<b>0.83</b>
<b>Summary Statistics</b>					
Count:	13	13	13	11	9
Average:	0.27	0.29	0.24	0.26	0.27
Median:	0.20	0.17	0.16	0.18	0.22
Standard Dev.:	0.23	0.41	0.28	0.23	0.22
Minimum:	0.08	0.09	0.10	0.11	0.12
Maximum:	<b>0.85</b>	<b>1.60</b>	<b>1.13</b>	<b>0.91</b>	<b>0.83</b>
Range:	0.77	1.52	1.04	0.80	0.71

<sup>a</sup> Calculation of column average gross SOF used on-site results unless off-site results were available.

<sup>b</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1 and **bolded red** SOF values indicate a result >1.

Table 19-7 Systematic Borehole Column Average Net SOF Results

Sample Location	Core Depth Interval (m)				
	0-1	0-2	0-3	0-4	0-5
	Combined Results for Column Average Net SOF <sup>a</sup>				
S01	0.14	0.06	0.03	--	--
S02	0.00	0.00	0.00	0.00	--
S03	0.02	0.04	0.03	--	--
S04	0.06	0.01	0.00	0.01	0.01
S06	0.10	0.08	0.06	0.10	0.08
S07	0.14	0.09	0.07	0.09	0.09
S08	<b>0.50</b>	0.36	0.25	0.18	--
S09	0.00	0.00	0.00	0.04	0.08
S11	0.01	0.00	0.00	0.01	0.04
S12	0.00	0.00	0.00	0.00	0.00
S13	0.02	0.03	0.04	0.04	0.04
S14	0.06	0.00	0.01	0.13	0.14
S15	<b>0.71</b>	<b>1.46</b>	<b>0.99</b>	<b>0.77</b>	<b>0.69</b>
<b>Summary Statistics</b>					
Count:	13	13	13	11	9
Average:	0.14	0.16	0.11	0.12	0.13
Median:	0.06	0.03	0.03	0.04	0.08
Standard Dev.:	0.22	0.40	0.27	0.22	0.21
Minimum:	0.00	0.00	0.00	0.00	0.00
Maximum:	<b>0.71</b>	<b>1.46</b>	<b>0.99</b>	<b>0.77</b>	<b>0.69</b>
Range:	0.71	1.46	0.99	0.77	0.69

<sup>a</sup> Calculation of column average gross SOF used on-site results unless off-site results were available.

<sup>b</sup> **Bolded orange** SOF values indicate a result >0.5 but ≤1 and **bolded red** SOF values indicate a result >1.

As discussed in Section 19.2, the Class 2 investigation level for subsurface material is a gross SOF of 1.33. This investigation level was only exceeded at sample location S15 at 0-2 m (Table 19-6) with a column average gross SOF of 1.60, due to the elevated sample at 1-2 m (Table 19-3). This area was not investigated due to safety concerns and its proximity to the chlorine tanks. The Class 1 investigation level for subsurface material is similarly calculated but with six instead of two standard deviations of background. The Class 1 action level was a gross SOF of 1.69 and because S15 did not exceed this value, it was determined that by not investigating this area it was acceptable given the safety concerns. Section 19.5 discusses this deviation in further detail.

#### 19.4.1 Data Set Screening Analysis

Table 19-8 summarizes the results of the screening tests performed on the borehole subsurface FSS data in accordance with Pages 14-27 through 14-29 of the C-T Phase II DP. All applicable tests demonstrating compliance passed.

Table 19-8 Screening Tests Results – Subsurface Material

Screening Test	Test Value	Conclusion
<b>0 – 1 m</b>		
Min/Max	0.83	PASS
Low Level	N/A	Not applicable; Class 2 survey unit
DCGL	N/A	Not applicable; Min / Max < 1
EMC Limit	N/A	Not applicable; subsurface material
<b>0 – 2 m</b>		
Min/Max	1.58	FAIL; conduct DCGL test
Low Level	N/A	Not applicable; Class 2 survey unit
DCGL	0.14	PASS; conduct WRS test
EMC Limit	N/A	Not applicable; subsurface material
<b>0 – 3 m</b>		
Min/Max	1.11	FAIL; conduct DCGL test
Low Level	N/A	Not applicable; Class 2 survey unit
DCGL	0.09	PASS; conduct WRS test
EMC Limit	N/A	Not applicable; subsurface material
<b>0 – 4 m</b>		
Min/Max	0.89	PASS
Low Level	N/A	Not applicable; Class 2 survey unit
DCGL	N/A	Not applicable; Min / Max < 1
EMC Limit	N/A	Not applicable; subsurface material
<b>0 – 5 m</b>		
Min/Max	0.81	PASS
Low Level	N/A	Not applicable; Class 2 survey unit
DCGL	N/A	Not applicable; Min / Max < 1
EMC Limit	N/A	Not applicable; subsurface material

19.4.1.1 Min/Max

In accordance with Page 14-27 of the C-T Phase II DP, the Min/Max screening test value was calculated by subtracting the minimum reference area result from the maximum survey unit systematic result. Location 15 had the maximum survey unit systematic column average gross SOF of 0.85, 1.60, 1.13, 0.91, and 0.83 for 0-1 m, 0-2 m, 0-3 m, 0-4 m, and 0-5 m, respectively (from Table 19-6). Sample BH-Z-08 with a calculated gross SOF of 0.02 (from C-T Phase II DP Table B-1) was the minimum reference area result. The Min/Max screening test value was calculated to be 0.83, 1.58, 1.11, 0.89, and 0.81 for 0-1 m, 0-2 m, 0-3 m, 0-4 m, and 0-5 m, respectively. Because the test value was less than one for 0-1 m, 0-4 m, and 0-5 m, further computations are not required, i.e., DCGL<sub>w</sub> screening and Wilcoxon Rank Sum (WRS) tests. Because the test value was greater than one for 0-2 m and 0-3 m, further computations are required.

#### 19.4.1.2 Low Level

In accordance with Page 14-27 of the C-T Phase II DP, the Low Level screening test is not applicable to Class 1 survey units.

#### 19.4.1.3 DCGL<sub>W</sub>

In accordance with Page 14-28 of the C-T Phase II DP and because the Min/Max test value was greater than one for 0-2 m and 0-3 m, the DCGL<sub>W</sub> screening test value was calculated by subtracting the reference area average gross SOF from the survey unit column average gross SOF. The survey unit column average gross SOF was 0.29 and 0.24 for 0-2 m and 0-3 m, respectively (from Table 19-6). The reference area average gross SOF was calculated to be 0.15 using average activity concentrations from C-T Phase II DP Table 4-17. The DCGL<sub>W</sub> screening test value was calculated to be 0.14 and 0.09 for 0-2 m and 0-3 m, respectively. Because the tests values were less than one, the WRS test is required per C-T Phase II DP Table 14-6.

#### 19.4.1.4 EMC Limit

In accordance with Page 14-26 of the C-T Phase II DP, the DCGL<sub>EMC</sub> is not applicable to subsurface survey units, in this case the assessment of the subsurface material in the survey unit. Thus, the elevated measurement comparison (EMC) limit is not applicable.

### 19.4.2 WRS Test

In accordance with Page 14-29 of the C-T Phase II DP, because the Min/Max test value was greater than one and the DCGL<sub>W</sub> test was less than one for both 0-2 m and 0-3 m, the WRS Test was required to demonstrate compliance. The test was completed in accordance with Pages 14-29 and 14-30 of the C-T Phase II DP. The result was that the survey unit passed, with the calculation details provided in Table 19-9 and Table 19-10 for 0-2 m and 0-3 m, respectively.

Table 19-9 WRS Test Results – 0-2 m

Sample ID / Location	Area	Combined On-Site and Off-Site Results			
		Data (SOF)	Adjusted Data (SOF)	Ranks	RA Ranks
BH-013	RA	0.11	1.11	20	20
BH-016	RA	0.42	1.42	27	27
BH-028	RA	0.10	1.10	19	19
BH-031	RA	0.09	1.09	16	16
BH-034	RA	0.29	1.29	26	26
BH-037	RA	0.22	1.22	23	23
BH-045	RA	0.10	1.10	18	18
BH-053	RA	0.16	1.16	21	21
BH-065	RA	0.23	1.23	24	24
BH-083	RA	0.07	1.07	15	15
BH-091	RA	0.24	1.24	25	25
BH-093	RA	0.10	1.10	17	17
BH-099	RA	0.22	1.22	22	22
BH-Z-02	RA	0.07	1.07	14	14
BH-Z-09	RA	0.05	1.05	13	13
S01	SU	0.19	0.19	9	0
S02	SU	0.10	0.10	2	0
S03	SU	0.18	0.18	8	0
S04	SU	0.15	0.15	6	0
S06	SU	0.22	0.22	10	0
S07	SU	0.23	0.23	11	0
S08	SU	0.50	0.50	12	0
S09	SU	0.09	0.09	1	0
S11	SU	0.11	0.11	4	0
S12	SU	0.11	0.11	3	0
S13	SU	0.17	0.17	7	0
S14	SU	0.12	0.12	5	0
S15	SU	1.60	1.60	28	0
Sum:				406	300
Critical Value:				253	
<b>Conclusion:</b>				<b>PASS</b>	



Table 19-10 WRS Test Results – 0-3 m

Sample ID / Location	Area	Combined On-Site and Off-Site Results			
		Data (SOF)	Adjusted Data (SOF)	Ranks	RA Ranks
BH-013	RA	0.11	1.11	20	20
BH-016	RA	0.42	1.42	28	28
BH-028	RA	0.10	1.10	19	19
BH-031	RA	0.09	1.09	16	16
BH-034	RA	0.29	1.29	27	27
BH-037	RA	0.22	1.22	24	24
BH-045	RA	0.10	1.10	18	18
BH-053	RA	0.16	1.16	22	22
BH-065	RA	0.23	1.23	25	25
BH-083	RA	0.07	1.07	15	15
BH-091	RA	0.24	1.24	26	26
BH-093	RA	0.10	1.10	17	17
BH-099	RA	0.22	1.22	23	23
BH-Z-02	RA	0.07	1.07	14	14
BH-Z-09	RA	0.05	1.05	13	13
S01	SU	0.16	0.16	7	0
S02	SU	0.11	0.11	3	0
S03	SU	0.17	0.17	8	0
S04	SU	0.14	0.14	5	0
S06	SU	0.21	0.21	10	0
S07	SU	0.21	0.21	11	0
S08	SU	0.40	0.40	12	0
S09	SU	0.10	0.10	2	0
S11	SU	0.11	0.11	4	0
S12	SU	0.10	0.10	1	0
S13	SU	0.17	0.17	9	0
S14	SU	0.14	0.14	6	0
S15	SU	1.13	1.13	21	0
Sum:				406	307
Critical Value:				253	
<b>Conclusion:</b>				<b>PASS</b>	

### 19.4.3 Retrospective Analysis

A retrospective analysis was performed of the FSS results to determine whether the results met the survey design objectives, in accordance with Page 14-30 of the C-T Phase II DP.

Table 19-11, Table 19-12, Table 19-13, Table 19-14, and Table 19-15 provide the results of the retrospective analysis for 0-1 m, 0-2 m, 0-3 m, 0-4 m, and 0-5 m, respectively. Because the actual sample size exceeded the retrospective value sample size 0-1 m, 0-3 m, and 0-4 m, the conclusion is that the survey design objectives were met. For 0-2 m and 0-5 m, the actual sample size was less than the retrospective value sample size; however, the retrospective sample size includes an increase of 20% (to account for lost samples, etc.) When removing the 20% increase in retrospective sample size, the actual sample size exceeded the retrospective value sample size for both 0-2 m and 0-5 m and the conclusion is that the survey design objectives were met.

**Table 19-11 Retrospective Analysis – 0-1 m**

Parameter	<i>A Priori</i> Value	Retrospective Value Based on FSS Results (Gross SOF)
Upper Bound of Gray Region	DCGL = 1	1
Lower Bound of Gray Region	0.5 x DCGL = 0.5	0.27
Spatial Variability (standard deviation)	1/6 x DCGL = 0.17	0.23
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	3.1
Calculated N/2 Sample Size	15 <sup>a</sup>	10
Actual N/2 Sample Size	--	13

<sup>a</sup>The *a priori* value of 15 for the N/2 sample size was determined to be a conservative value that would allow application of either the Sign or WRS test. The *a priori* value for N/2 is 10 based on MARSSIM Table 5.3.

**Table 19-12 Retrospective Analysis – 0-2 m**

Parameter	<i>A Priori</i> Value	Retrospective Value Based on FSS Results (Gross SOF)
Upper Bound of Gray Region	DCGL = 1	1
Lower Bound of Gray Region	0.5 x DCGL = 0.5	0.29
Spatial Variability (standard deviation)	1/6 x DCGL = 0.17	0.41
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	1.7
Calculated N/2 Sample Size	15 <sup>a</sup>	15 (× 0.8 = 12)
Actual N/2 Sample Size	--	13

<sup>a</sup>The *a priori* value of 15 for the N/2 sample size was determined to be a conservative value that would allow application of either the Sign or WRS test. The *a priori* value for N/2 is 10 based on MARSSIM Table 5.3.

**Table 19-13 Retrospective Analysis – 0-3 m**

Parameter	<i>A Priori</i> Value	Retrospective Value Based on FSS Results (Gross SOF)
Upper Bound of Gray Region	DCGL = 1	1
Lower Bound of Gray Region	0.5 x DCGL = 0.5	0.24
Spatial Variability (standard deviation)	1/6 x DCGL = 0.17	0.28
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	2.7
Calculated N/2 Sample Size	15 <sup>a</sup>	11
Actual N/2 Sample Size	--	13

<sup>a</sup>The *a priori* value of 15 for the N/2 sample size was determined to be a conservative value that would allow application of either the Sign or WRS test. The *a priori* value for N/2 is 10 based on MARSSIM Table 5.3.

**Table 19-14 Retrospective Analysis – 0-4 m**

Parameter	<i>A Priori</i> Value	Retrospective Value Based on FSS Results (Gross SOF)
Upper Bound of Gray Region	DCGL = 1	1
Lower Bound of Gray Region	0.5 x DCGL = 0.5	0.26
Spatial Variability (standard deviation)	1/6 x DCGL = 0.17	0.23
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	3.2
Calculated N/2 Sample Size	15 <sup>a</sup>	10
Actual N/2 Sample Size	--	11

<sup>a</sup>The *a priori* value of 15 for the N/2 sample size was determined to be a conservative value that would allow application of either the Sign or WRS test. The *a priori* value for N/2 is 10 based on MARSSIM Table 5.3.

**Table 19-15 Retrospective Analysis – 0-5 m**

Parameter	<i>A Priori</i> Value	Retrospective Value Based on FSS Results (Gross SOF)
Upper Bound of Gray Region	DCGL = 1	1
Lower Bound of Gray Region	0.5 x DCGL = 0.5	0.27
Spatial Variability (standard deviation)	1/6 x DCGL = 0.17	0.22
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	3.3
Calculated N/2 Sample Size	15 <sup>a</sup>	10 (× 0.8 = 8)
Actual N/2 Sample Size	--	9

<sup>a</sup>The *a priori* value of 15 for the N/2 sample size was determined to be a conservative value that would allow application of either the Sign or WRS test. The *a priori* value for N/2 is 10 based on MARSSIM Table 5.3.

## 19.5 DEVIATIONS

In accordance with the second bullet in Section 14.5 of the C-T Phase II DP, the FSSR is required to list changes made in the FSS from what was proposed in the DP. Two deviations were noted.

1. Page 14-27 of the C-T Phase II DP indicated that the “data set for the survey unit will be processed within a database using screening software developed and verified for the project.” This database was not developed; instead, a combination of Microsoft® Excel® spreadsheets and hand calculations was utilized. This deviation is not significant and does not affect the data collection or assessment.
2. The Class 1 investigation level for subsurface material (gross SOF of 1.69) was used to determine if further investigation was warranted at systematic location S15 rather than the Class 2 investigation level (gross SOF of 1.33). Systematic sample location 15 is located directly in front of a Chlorine tank shed off the northwest corner of

Building 200W. Although a Class 2 survey unit, the maximum column average of 1.60 for 0-2 meters was below the Class 1 investigation level. Considering the proximity to the Chlorine tank, overhead obstructions and the potential that any excavation in the area could compromise the Chlorine system, additional investigation samples were not collected as the area wouldn't warrant any further investigation if it were a Class 1 area. Given the safety concerns and the fact that the column average result did not exceed the Class 1 investigation level and the sampling density was the same as used for Class 1 survey units, this deviation was warranted due to the aforementioned safety concerns.

## **19.6 NRC INSPECTIONS**

A summary of U.S. Nuclear Regulatory Commission (NRC) inspections applicable to the FSS are provided in Section 5.8 of this FSSR. The scope of the inspections included, but was not limited to: review of project plans, interviewing of project personnel, evaluation of the on-site laboratory, and independent confirmatory surveys of affected areas conducted by the NRC. No violations were identified. No findings of significance were identified.

## **19.7 CONCLUSION**

FSS data were verified to be reliable, appropriately documented, and technically defensible. Specifically, the following conclusions are made:

- The instruments used to collect the data were capable of detecting the radiation type (i.e., gamma) at or below the release criteria (described in Sections 4.4 and 4.5 of this FSSR).
- The calibration of the instruments used to collect the data was current and radioactive sources used for calibration were National Institute of Standards and Technology (NIST) traceable (described in Section 5.4 of this FSSR). Specific records available upon request.
- Instrument response was checked before instrument use each day, at minimum (described in Section 5.4 of this FSSR). Specific records available upon request.
- The survey methods used to collect the data were appropriate for the media and type of radiation being measured (described in Section 4.4, 4.5, and 4.6 of this FSSR).
- The custody of samples collected for laboratory analysis was tracked from the point of collection until final results were obtained (described in Section 5.5.2 of this FSSR). Specific records available upon request.
- The survey data consist of qualified measurement results that are representative of the area of interest.
- Areas identified with elevated residual radioactivity (i.e. SOF > 1.0) were appropriately investigated.

All the applicable screening tests passed and the retrospective analysis found that the survey design objectives were met. SU13 meets the industrial use scenario release criterion as established in the C-T Phase II DP Chapter 5; and therefore, satisfies the unrestricted release provisions of Title 10, Code of Federal Regulations (CFR), Part 20, Subpart E.

## **19.8 REFERENCES**

Mallinckrodt, *Mallinckrodt Columbium-Tantalum Phase II Decommissioning Plan*, Revision 2, August 2008.