

# Phase II Final Status Survey Report Mallinckrodt Columbiu-m-Tantalum Plant

St. Louis, Missouri

## Chapter 23

Project No. 137131

Revision 0

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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
DCGL	derived concentration guideline level
DP	decommissioning plan
DQO	data quality objectives
EMC	elevated measurement comparison
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
WRS	Wilcoxon Rank Sum

## 23.0 RESULTS SUMMARY FOR PLANT 5 SUBSURFACE SU17

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 SU17 in accordance with Columbium-Tantalum (C-T) Phase II Decommissioning Plan (DP) Section 14.5. The FSS for this Class 1 survey unit was completed by AECOM Technical Services (AECOM) in April 2012. The SU17 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.

### 23.1 OVERVIEW

SU17 is a Class 1 survey unit located in the west central portion of C-T Plant 5. The survey unit is approximately 305 square meters ( $m^2$ ) in size, which is less than the size limit of 3,000  $m^2$  for Class 1 survey units for subsurface material (per C-T Phase II DP, Table 14-4). Class 1 was the appropriate classification because the survey unit contained residual radioactivity that exceeded the  $DCGL_w$  prior to remediation. Figure 23-1 shows the location of SU17 within the Plant 5 area.

Figure 23-2 is a photograph of SU17 that was taken during the FSS, following remediation. The survey unit is bounded on the west and south by SU10, the east by SU16 and SU19, and the north by SU05 and SU07. Soil and related debris were removed from the area to an excavated depth range of approximately 4 to 16.5 feet (ft) below grade surface (bgs). A loading dock for Building 250 and a chain link fence extending from the dock form the western border of SU17. Due to the need to support these structures, the soil left in place was sloped at a 45 degree angle. The soils left in place to support the loading dock (adjoining the southeast corner of Building 250) are included as part of SU17. A 10-inch clay pipe running east-west along the northern border of SU17 was discovered at approximately 16 ft bgs as shown in Figure 23-3. A section of that pipe that exhibited elevated contamination was removed.



Figure 23-1 Location of Subsurface SU17 in C-T Plant 5



**Figure 23-2 Photograph Looking Southwest Towards SU17**

## **23.2 REMEDIAL ACTION AND RADIOLOGICAL SAMPLING SUMMARY**

Extensive post-remediation soil sampling, shown in Figure 23-3, was performed by AECOM after GWS indicated successful remediation. The soil sampling demonstrated that the survey unit was ready for FSS. In addition, volumetric “channel” sampling was performed on the south wall and west wall (shown in Figure 23-4) of SU17. A 1-ft wide vertical “channel” was designated on the wall and separated into 1-meter (m) vertical lengths. A representative composite sample was then taken from each 1-m length of the channel. Table 23-1 provides the results for the two types of post-remediation samples: 15 characterization/excavation guidance grab samples and 13 volumetric “channel” characterization samples, five (3 to 4 m bgs) along the south wall and eight (0-1 m, 1-2 m, and 2-3 m bgs) along the west wall. The south wall and west wall “channel” samples confirmed the suitability of the excavated floor area for FSS.

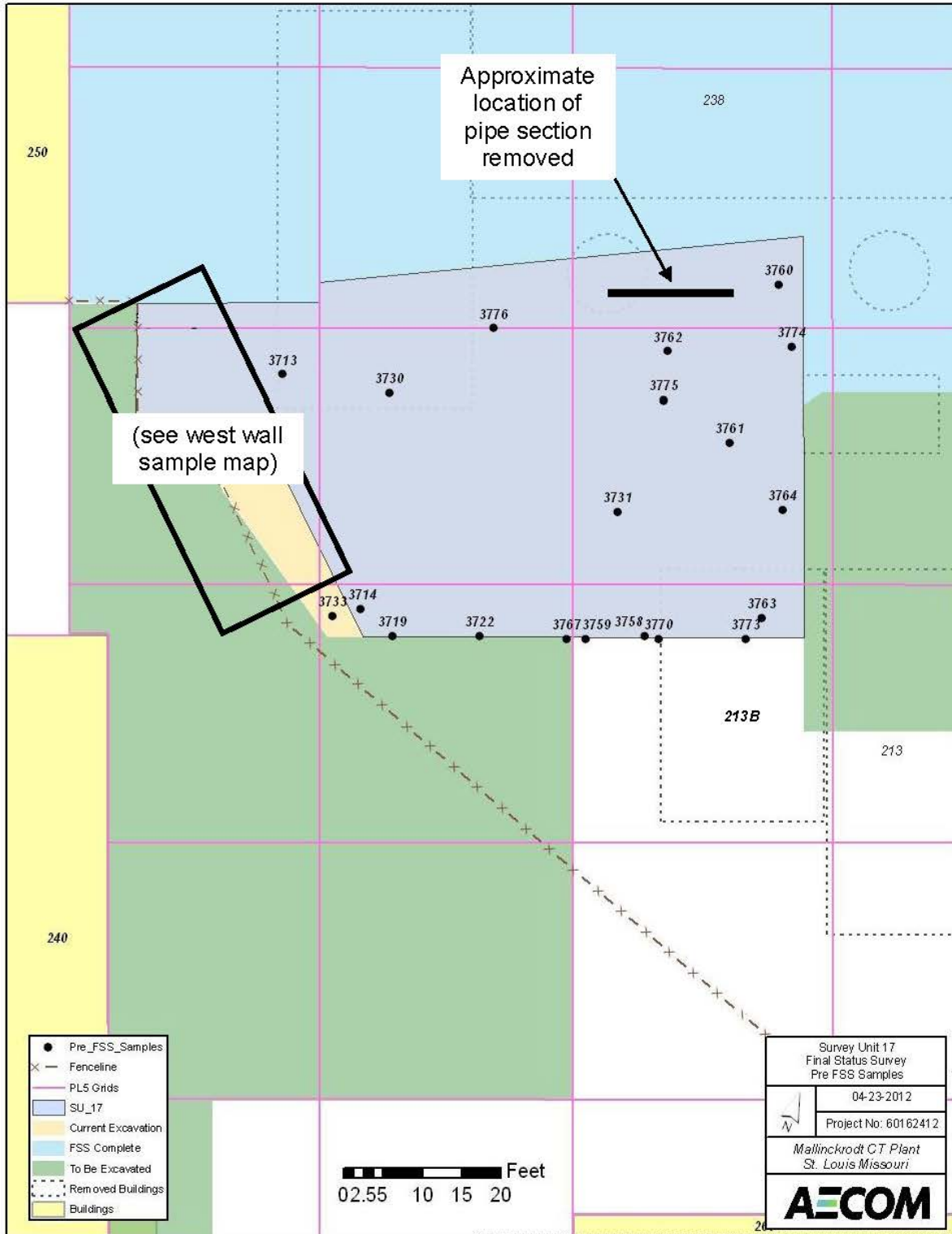
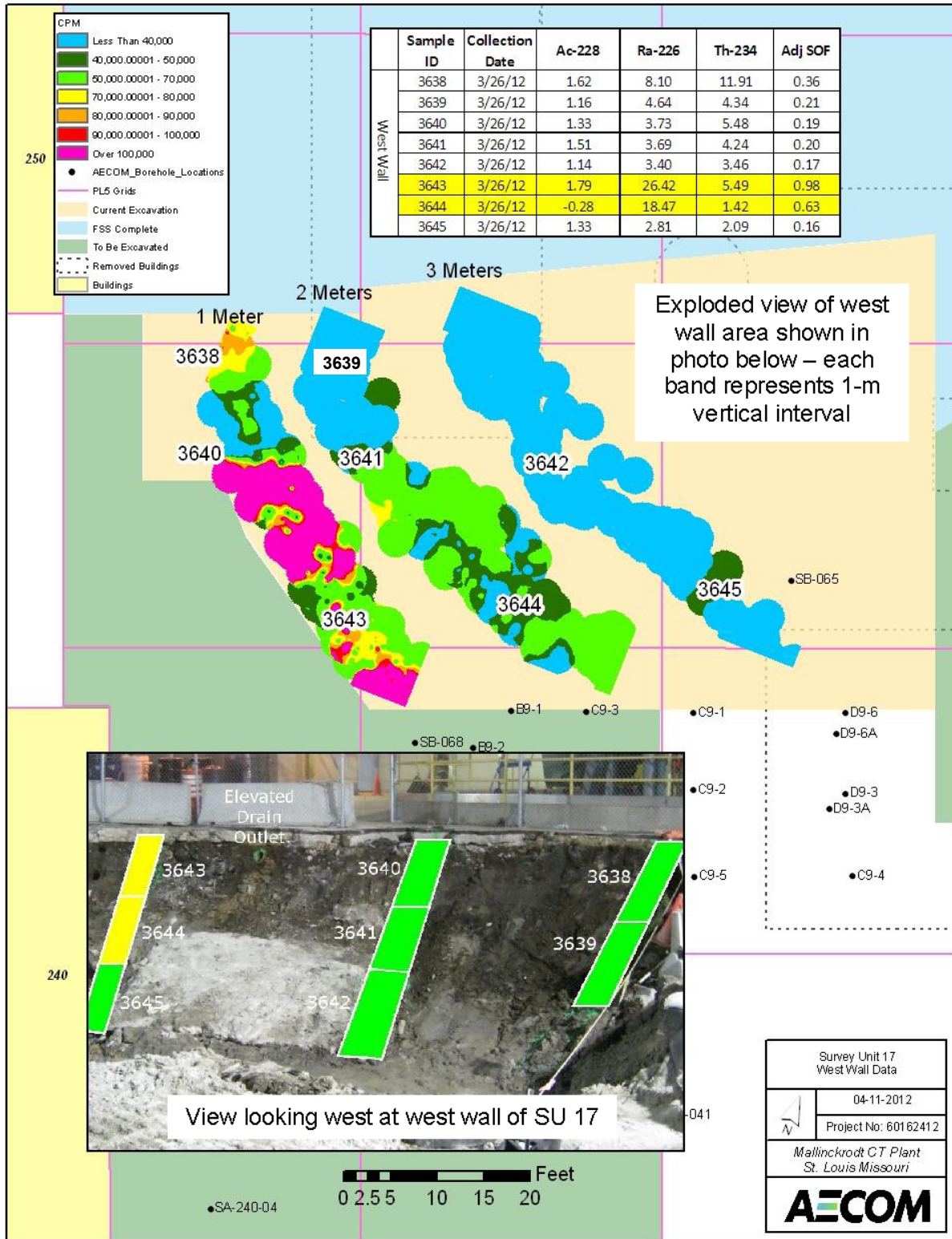


Figure 23-3 Post-Remediation Soil Sampling Locations



**Figure 23-4 West Wall Sampling**

The "Elevated Drain Outlet" shown above was removed during remediation of adjacent survey unit SU10.



Table 23-1 Post-Remediation Sampling Analytical Results

Sample ID	Collection Date	On-Site Results			Gross SOF
		Concentration (pCi/g)			
		<sup>232</sup> Th	<sup>226</sup> Ra	<sup>238</sup> U	
<b>Characterization / Excavation Guidance Samples</b>					
3713	4/4/2012	1.14	1.67	1.66	0.11
3714		0.96	1.42	1.54	0.09
3730	4/5/2012	1.00	1.33	1.97	0.09
3731		0.85	1.65	0.74	0.09
3733 <sup>a</sup>		1.02	1.68	1.13	0.10
3758	4/10/2012	1.26	2.30	1.21	0.13
3759		1.19	2.26	1.43	0.13
3760		0.45	4.72	7.11	0.19
3761		1.39	2.13	0.60	0.13
3762		1.28	1.38	1.21	0.10
3763		1.14	2.41	2.00	0.13
3764		1.51	4.01	2.84	0.21
3774		4/12/2012	1.06	2.76	19.36
3775	1.07		1.50	1.78	0.10
3776	1.53		2.73	3.22	0.16
<b>South Wall "Channel" Volumetric Characterization Samples (3-4 m bgs)</b>					
3719	4/4/2012	1.24	2.98	4.00	0.16
3722		1.08	1.88	3.58	0.12
3767	4/11/2012	0.57	1.19	6.22	0.08
3770		1.14	1.11	2.44	0.09
3773		2.90	23.11	16.51	0.93
<b>West Wall "Channel" Volumetric Characterization Samples</b>					
3638	3/26/2012	1.62	8.10	11.91	0.36
3639		1.16	4.64	4.34	0.21
3640		1.33	3.73	5.48	0.19
3641		1.51	3.69	4.24	0.20
3642		1.14	3.40	3.46	0.17
3643		1.79	26.42	5.49	0.98
3644		-0.28	18.47	1.42	0.63
3645		1.33	2.81	2.09	0.16

<sup>a</sup> Collected from what would eventually be within the extent of SU10.

### 23.3 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.

### 23.3.1 Gamma Scans

A gamma walk-over survey (GWS) was performed over 100% of the excavated area to locate radiation anomalies that might indicate areas with elevated residual radioactivity where further data collection (i.e., biased soil sampling) was warranted.

### 23.3.2 Soil Sampling

Soil samples to be used for the statistical test were collected at a frequency and at representative locations throughout SU17 such that a statistically sound conclusion regarding the radiological condition of the survey unit could be developed. Additional biased soil samples were also collected at a location in the trench after the clay pipe was removed and at locations of elevated residual radioactivity identified by GWS. Figure 23-5 provides the GWS results and soil sampling locations. A total of 18 (15 systematic, 1 pipe trench post-remediation, and 2 GWS biased) soil samples were collected over the areal footprint SU17.

All soil samples were analyzed on site via gamma spectroscopy analysis. Table 23-2 provides the sample results and summary statistics for the 15 systematic samples. Table 23-3 provides the sample results for the 3 GWS biased samples.

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 sum of fractions (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.

To mitigate the risk of backfilling, the on-site laboratory analytical results were reviewed to determine the likelihood of the survey unit failing to meet the criteria for radiological release. The on-site laboratory, by design, reported conservative sample results.

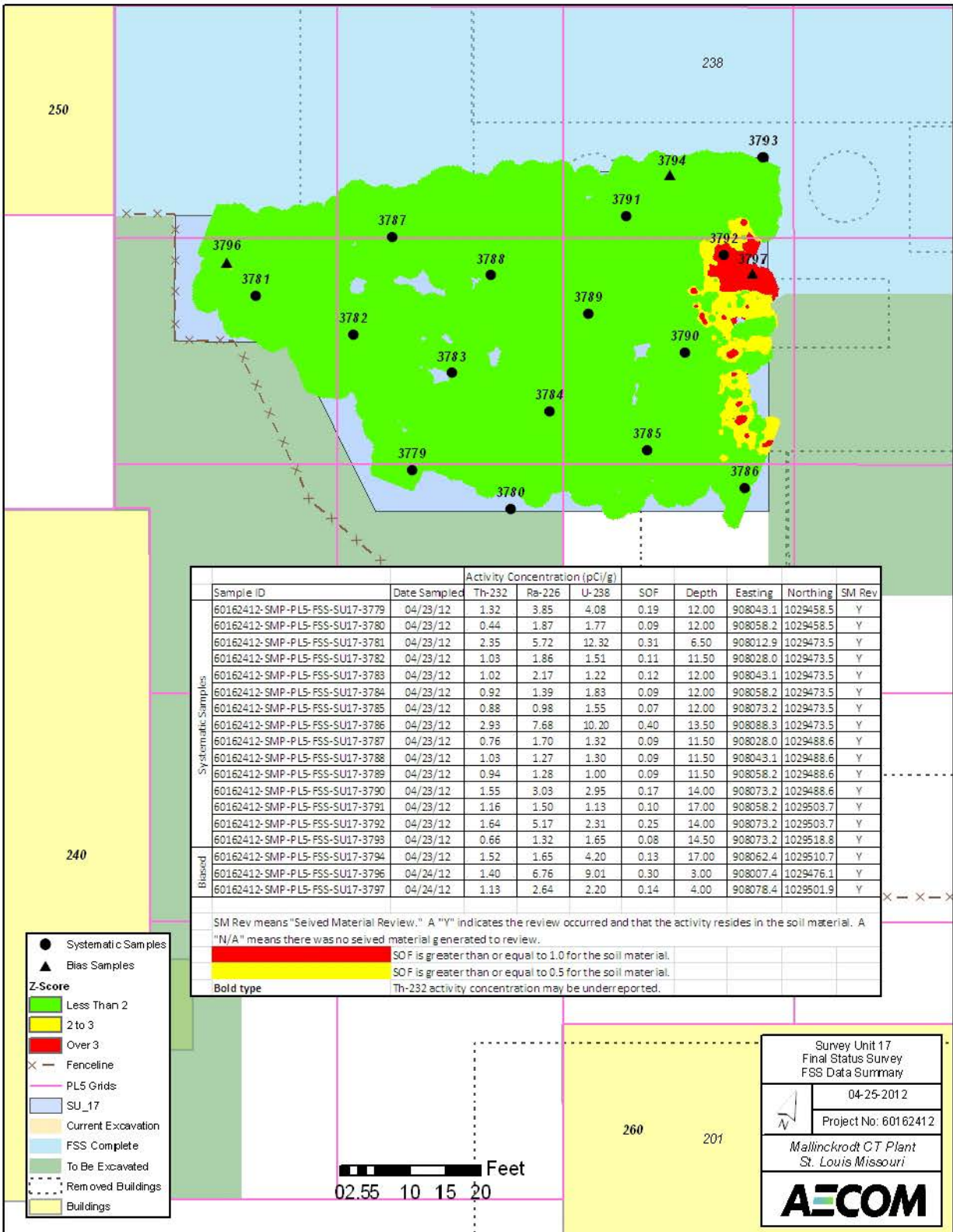


Figure 23-5 GWS and Soil Sampling Locations

Table 23-2 Gamma Spectroscopy Systematic Sample Analytical Results

Sample ID	Depth (ft bgs)	On-Site Results											Off-Site Results <sup>a</sup>											On-Site/ Off-Site Gross SOF Ratio	
		Concentration (pCi/g)									SOF		Concentration (pCi/g)									SOF			
		<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U			Gross	Net <sup>b</sup>	<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U			Gross	Net <sup>b</sup>		
Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)			MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)			MDC	
3779	12	1.32	0.28	0.05	3.85	1.09	0.73	4.08	1.40	0.81	0.19	0.05	1.42	0.24	0.13	1.37	0.19	0.06	1.51	0.19	0.05	0.11	0.01	1.77	
3780	12	0.44	0.11	0.20	1.87	0.75	0.52	1.77	0.97	0.60	0.08	0.00	1.28	0.26	0.17	1.12	0.19	0.08	1.41	0.21	0.09	0.09	0.00	0.90	
3781	6.5	2.35	0.42	0.04	5.72	1.90	1.34	12.32	2.32	1.18	0.31	0.16	2.33	0.36	0.18	2.40	0.35	0.09	2.63	0.34	0.09	0.18	0.04	1.70	
3782	11.5	1.03	0.18	0.06	1.86	0.71	0.49	1.51	0.76	0.50	0.11	0.00	1.19	0.27	0.18	1.31	0.20	0.09	1.20	0.18	0.09	0.10	0.00	1.13	
3783	12	1.02	0.23	0.08	2.17	0.74	0.50	1.22	0.67	0.46	0.12	0.00	1.17	0.21	0.12	1.09	0.15	0.06	1.20	0.16	0.05	0.09	0.00	1.35	
3784	12	0.92	0.25	0.09	1.39	0.70	0.50	1.83	0.79	0.50	0.09	0.00	1.06	0.20	0.11	1.08	0.16	0.05	1.13	0.15	0.05	0.08	0.00	1.07	
3785	12	0.88	0.24	0.09	0.98	0.64	0.47	1.55	0.83	0.51	0.07	0.00	0.77	0.15	0.12	0.80	0.11	0.05	0.76	0.12	0.05	0.06	0.00	1.20	
3786	13.5	2.93	0.42	0.09	7.68	1.71	1.20	10.20	1.92	1.11	0.40	0.25	3.50	0.52	0.18	7.06	0.90	0.09	7.70	0.89	0.09	0.40	0.25	1.00	
3787	11.5	0.76	0.19	0.05	1.70	0.76	0.54	1.32	0.70	0.46	0.09	0.00	0.87	0.18	0.12	1.11	0.15	0.06	1.16	0.16	0.06	0.08	0.00	1.21	
3788	11.5	1.03	0.23	0.06	1.27	0.65	0.47	1.30	0.75	0.47	0.09	0.00	1.01	0.18	0.11	0.95	0.15	0.04	1.12	0.14	0.04	0.08	0.00	1.15	
3789	11.5	0.94	0.16	0.08	1.28	0.70	0.52	1.00	0.71	0.50	0.08	0.00	1.20	0.19	0.11	1.07	0.15	0.04	1.06	0.14	0.05	0.09	0.00	0.96	
3790	14	1.55	0.30	0.08	3.03	0.97	0.67	2.95	0.89	0.57	0.17	0.03	1.40	0.37	0.22	2.48	0.32	0.10	2.62	0.34	0.11	0.15	0.00	1.17	
3791	17	1.16	0.17	0.07	1.50	0.72	0.52	1.13	0.71	0.51	0.10	0.00	1.38	0.23	0.12	1.29	0.18	0.06	1.32	0.16	0.05	0.10	0.00	0.97	
3792	14	1.64	0.32	0.09	5.17	1.06	0.65	2.31	1.07	0.70	0.25	0.10	1.56	0.30	0.17	4.37	0.54	0.08	4.54	0.52	0.09	0.22	0.07	1.12	
3793	14.5	0.66	0.13	0.06	1.32	0.65	0.46	1.65	0.80	0.49	0.07	0.00	0.85	0.20	0.15	1.08	0.17	0.07	1.22	0.18	0.08	0.07	0.00	1.01	
<b>Summary Statistics</b>																									
Count:	15				15						15	15	15						15			15	15	15	
Average:	1.24				2.72						0.15	0.04	1.40						1.90			2.04	0.13	0.03	1.18
Median:	1.03				1.86						0.10	0.00	1.20						1.12			1.22	0.09	0.00	1.13
Standard Dev.:	0.66				2.00						0.10	0.08	0.69						1.70			1.84	0.09	0.07	0.25
Minimum:	0.44				0.98						0.07	0.00	0.77						0.80			0.76	0.06	0.00	0.90
Maximum:	2.93				7.68						0.40	0.25	3.50						7.06			7.70	0.40	0.25	1.77
Range:	2.49				6.70						0.33	0.25	2.73						6.27			6.95	0.34	0.25	0.87

<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> Calculated as discussed in Section 23.3.2.

Table 23-3 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	
		Concentration (pCi/g)									SOF		Concentration (pCi/g)									SOF			
		<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U			Gross	Net <sup>b</sup>	<sup>232</sup> Th			<sup>226</sup> Ra			<sup>238</sup> U			Gross	Net <sup>b</sup>		
Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>b</sup>	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Result	Uncert. (2σ)	MDC	Gross	Net <sup>b</sup>	
<b>Pipe Trench Post-Remediation Sample</b>																									
3794	17	1.52	0.25	0.10	1.65	1.20	0.93	4.20	1.07	0.66	0.13	0.01	1.69	0.27	0.15	1.43	0.21	0.08	1.50	0.20	0.08	0.12	0.02	1.03	
<b>GWS Biased Samples</b>																									
3796	3	1.40	0.38	0.11	6.76	1.96	1.35	9.01	2.16	1.20	0.30	0.16	2.09	0.36	0.18	3.93	0.49	0.08	4.20	0.48	0.08	0.23	0.08	1.33	
3797	4	1.13	0.22	0.10	2.64	0.90	0.62	2.20	0.98	0.62	0.14	0.00	1.27	0.29	0.19	2.33	0.31	0.09	2.39	0.31	0.09	0.14	0.00	1.03	

<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> Calculated as discussed in Section 23.3.2.

### 23.3.3 Core Boring

The C-T Phase II DP, Table 4-15, provided characterization borehole results. Of the locations provided in the table, one was collected within the extent of SU17: BH-086. Table 23-4 provides the data for this location. The results indicate that beyond the excavation extent, additional subsurface contamination is not reasonably expected. Therefore, in accordance with Page 14-22 of the C-T Phase II DP, FSS core sampling or measurements were not performed.

**Table 23-4 Characterization Borehole Results**

Location ID	Sample Depth (ft)	Activity Concentration (pCi/g)			SOF <sup>a</sup>	
		<sup>232</sup> Th	<sup>226</sup> Ra	<sup>238</sup> U	Gross	Net <sup>b</sup>
BH-086	1 - 1.5	1.08	3.63	12.90	0.19	0.05
	3 - 4.5	8.60	1.71	4.37	0.42	0.31
	6 - 7.5	27.50	7.10	7.70	<b>1.40</b>	<b>1.26</b>
	7.5 - 9	2.22	1.36	1.63	0.14	0.04

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

<sup>b</sup> Calculated as discussed in Section 23.3.2.

## 23.4 DATA ANALYSIS

The data analysis 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.

### 23.4.1 Elevated Area Evaluation

There were no elevated areas identified in SU17.

### 23.4.2 Data Set Screening Analysis

Table 23-5 summarizes the results of the screening tests performed in accordance with Pages 14-27 through 14-29 of the C-T Phase II DP. All applicable tests demonstrating compliance passed.

**Table 23-5 Screening Tests Results**

Screening Test	Test Value	Conclusion
Min/Max	0.38	PASS
Low Level	N/A	Not applicable; Class 1 survey unit
DCGL <sub>w</sub>	N/A	Not applicable; Min/Max < 1
EMC Limit	N/A	Not applicable; No elevated areas

#### 23.4.2.1 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. Sample 3786 with a gross SOF of 0.40 (from Table 23-2) was the maximum survey unit systematic result. 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 0.38. Because the test value was less than one, no further computations are required, i.e., DCGL<sub>W</sub> screening and Wilcoxon Rank Sum (WRS) tests.

#### 23.4.2.2 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.

#### 23.4.2.3 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 less than one, the DCGL<sub>W</sub> screening test was not applicable to this survey unit.

#### 23.4.2.4 EMC Limit

In accordance with Page 14-28 of the C-T Phase II DP, the elevated measurement comparison (EMC) Limit screening test was not applicable to this survey unit because no elevated areas were identified.

### 23.4.3 WRS Test

In accordance with Page 14-29 of the C-T Phase II DP and because the Min/Max test value was less than one, the WRS Test was not required to demonstrate compliance.

### 23.4.4 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 23-6 provides the results of the retrospective analysis. Because the actual sample size exceeded the retrospective value sample size, the conclusion is that the survey design objectives were met.

Table 23-6 Retrospective Analysis

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	0.13
Spatial Variability (standard deviation)	1/6 x DCGL = 0.17	0.087
Type I Error (false positive)	0.05	0.05
Type II Error (false negative)	0.05	0.05
Relative Shift	3	10
Calculated N/2 Sample Size	15 <sup>a</sup>	9
Actual N/2 Sample Size	--	15

<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.

### 23.5 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. Only one deviation was noted. 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.

### 23.6 NRC INSPECTIONS

A summary of 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 conducted by the NRC prior to and after backfilling. No violations were identified. No findings of significance were identified.

### 23.7 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 Sections 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 and the DCGL<sub>EMC</sub> properly applied.

All the applicable screening tests passed, the retrospective analysis found that the survey design objectives were met, and additional subsurface contamination was not reasonably suspected. SU17 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.

### **23.8 REFERENCES**

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