REV. 0

FINAL STATUS SURVEY EVALUATION FOR THE ACCESSIBLE SOILS WITHIN THE ST. LOUIS DOWNTOWN SITE VICINITY PROPERTIES WEST OF BROADWAY, MALLINCKRODT PLANTS 3, 8, 9, 11, AND PARKING LOTS

ST. LOUIS, MISSOURI

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Formerly Utilized Sites Remedial Action Program

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ACRONYMS AND ABBREVIATIONS

Δ/σ	relative shift
σ	Standard deviation
Ac	actinium
AD	averted dose
AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BNI	Bechtel National, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm	centimeter
COC	contaminant of concern
$DCGL_W$	Derived Concentration Guideline Level for non-parametric test
DOD	Department of Defense
DOE	U.S. Department of Energy
DQA	data quality assessment
DQI	Data quality indicator
DQO	data quality objective
DT	Downtown
USEPA	U.S. Environmental Protection Agency
EPC	exposure point concentrations
ft	foot
FGR	federal guidance report
FS	Feasibility Study
FSS	Final Status Survey
FSSP	Final Status Survey Plan
FUSRAP	Formerly Utilized Sites Remedial Action Program
GPS	Global Positioning System
HISS	Hazelwood Interim Storage Site
LBGR	lower bound of the gray region
LCS	laboratory control samples
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
MED	Manhattan Engineer District
m	meter

ACRONYMS AND ABBREVIATIONS (CONT'D)

MS	Matrix spike
mrem/yr	millirem per year
NAD	normalized absolute difference
NaI	Sodium Iodide
NCP	National Oil and Hazardous Substances Contingency Plan
NRC	Nuclear Regulatory Commission
Pa	protactinium
pe	performance evaluation
pCi/g	picocuries per gram
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QCSR	Quality Control Summary Report
Ra	radium
RAO	Remedial action objectives
RG	remediation goal
RI	Remedial investigation
ROD	Record of Decision
RPD	relative percent difference
SAG	Sampling and Analysis Guide
SAIC	Science Applications International Corporation
SDG	Sample delivery group
SLDS	St. Louis Downtown Site
SOR	sum of ratios
SOR_G	sum of ratios (gross)
SOR_N	sum of ratios (net)
SU	survey unit
TEDE	total effective dose equivalent
Th	thorium
U	uranium
UCL_{95}	95% upper confidence limit
UMTRCA	Uranium Mill Tailing Radiation Control Act
USACE	United States Army Corps of Engineers
VP	vicinity property
WRS	Wilcoxon Rank Sum

1.0 INTRODUCTION

This report documents and assesses the final status survey (FSS) conducted as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP) St. Louis Downtown Site (SLDS) for Mallinckrodt Plants 3, 8, 9, 11 and parking lots (hereafter referred to as Mallinckrodt West), OJM Vicinity Property (VP) [DT-36], Dillion VP (DT-27), UAAA Local 1887 VP (DT-26), Eirten's Parlors VP (DT-25), Bremen Bank VP (DT-24), Worth Industries VP (DT-23), Tobin Electric VP (DT-22), Farve VP (DT-21), Richey VP (DT-20), Challenge Enterprises VP (DT-28), Midtown Garage VP (DT-29), and Zamzow Manufacturing VP (DT-30) (hereafter collectively referred to as the West of Broadway VPs). The SLDS consists of the Mallinckrodt Inc. property and the surrounding vicinity properties. The locations of these properties are shown in Figure 1.

The FSS was performed in accordance with the *Record of Decision for the St. Louis Downtown Site* (ROD) and the *Radiological Final Status Survey Plan for Accessible Soils within Mallinckrodt Property and the Vicinity Properties, Excluding Plants 1 and 2, and the City Property at the St. Louis Downtown Site* (FSSP) (USACE 2002a). It also uses the guidance provided in the Nuclear Regulatory Commission (NRC) *NMSS Decommissioning Standard Review Plan* NUREG-1727 (NRC 2000) and Multi-Agency Remediation Survey and Site Investigation Manual (MARSSIM) [Department of Defense (DOD) 2000]. In accordance with MARSSIM guidance, the West of Broadway VPs and Mallinckrodt West properties were divided into Class 2 and Class 3 areas for evaluation against clean up standards identified in the ROD.

One Class 2 [i.e., areas that have, potential or had prior to remediation, a potential for radioactive contaminants but are not expected to exceed the concentration based remedial goals (RGs)] land area survey unit (SU), (i.e., SU-1) was established on the properties shown in Figure 2. The Class 2 SU consisted of accessible soils of the property. The FSS of the Class 2 SU consisted of a gamma walkover survey and the collection of 21 systematic surface soil samples, 60 subsurface soil samples, and 10 biased surface soil samples and 13 biased subsurface soil samples.

One Class 3 (i.e., areas not expected to contain any residual radioactivity or are expected to contain levels at a small fraction of the RGs) land area SU, (i.e., SU-2) was established on the properties also shown in Figure 2. FSS of the Class 3 SU consisted of a gamma walkover survey and the collection of 24 random surface samples, 49 subsurface samples, 15 biased surface soil samples and 8 biased subsurface soil samples.

Risk and dose assessments, which are based on analysis of various pathways and realistic human exposure scenarios, are used to identify acceptable levels of residual radioactivy. These levels are known as RGs (remedial goals) and are provided in terms of mass activity concentrations [i.e. picocuries per gram (pCi/g)]. Where multiple radiological contaminants are present, the concentration-based RGs are expressed and evaluated using a "unity rule". The result of a unity rule calculation is referred to as a sum of ratios (SOR) and is based on the primary contaminants of concern (COC) at SLDS; a net sum of ratios (SOR_N) in excess of 1.0 reflects a soil sample that exceeds the RGs, if it represents an area greater than or equal to 100 square meters (m^2) in any 15 centimeter (cm) [0.5 foot (ft)] interval.

The ROD specifies applicable or relevant and appropriate requirements (ARARs), establishes clean-up standards for accessible soils, and provides that remedial actions shall be conducted so as to provide a reasonable assurance that the concentration of radium (Ra)-226 averaged over any area of 100 m^2 shall not exceed the background level by more than 5 pCi/g averaged over the

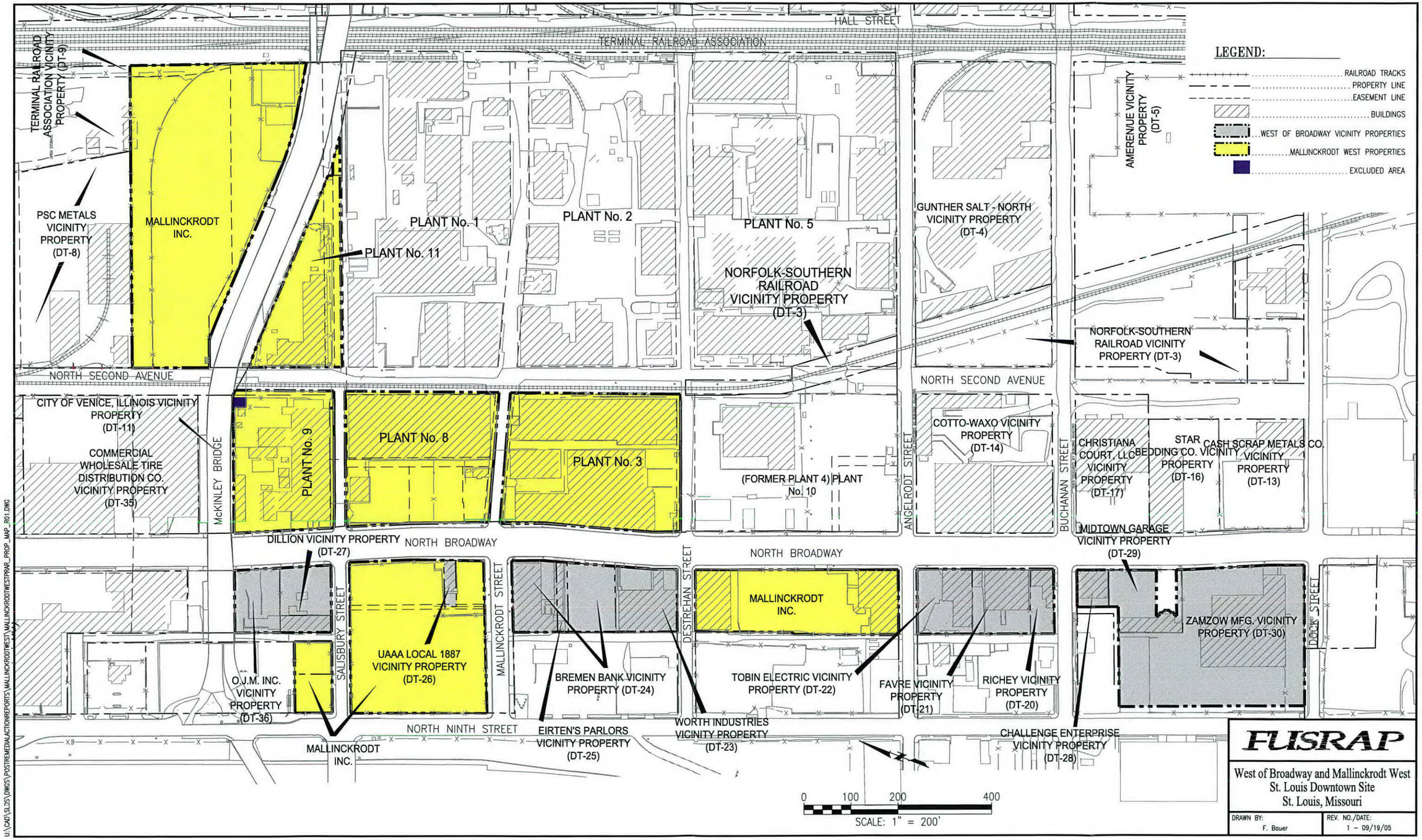

Figure 1. West of Broadway VPs and Mallinckrodt West Properties

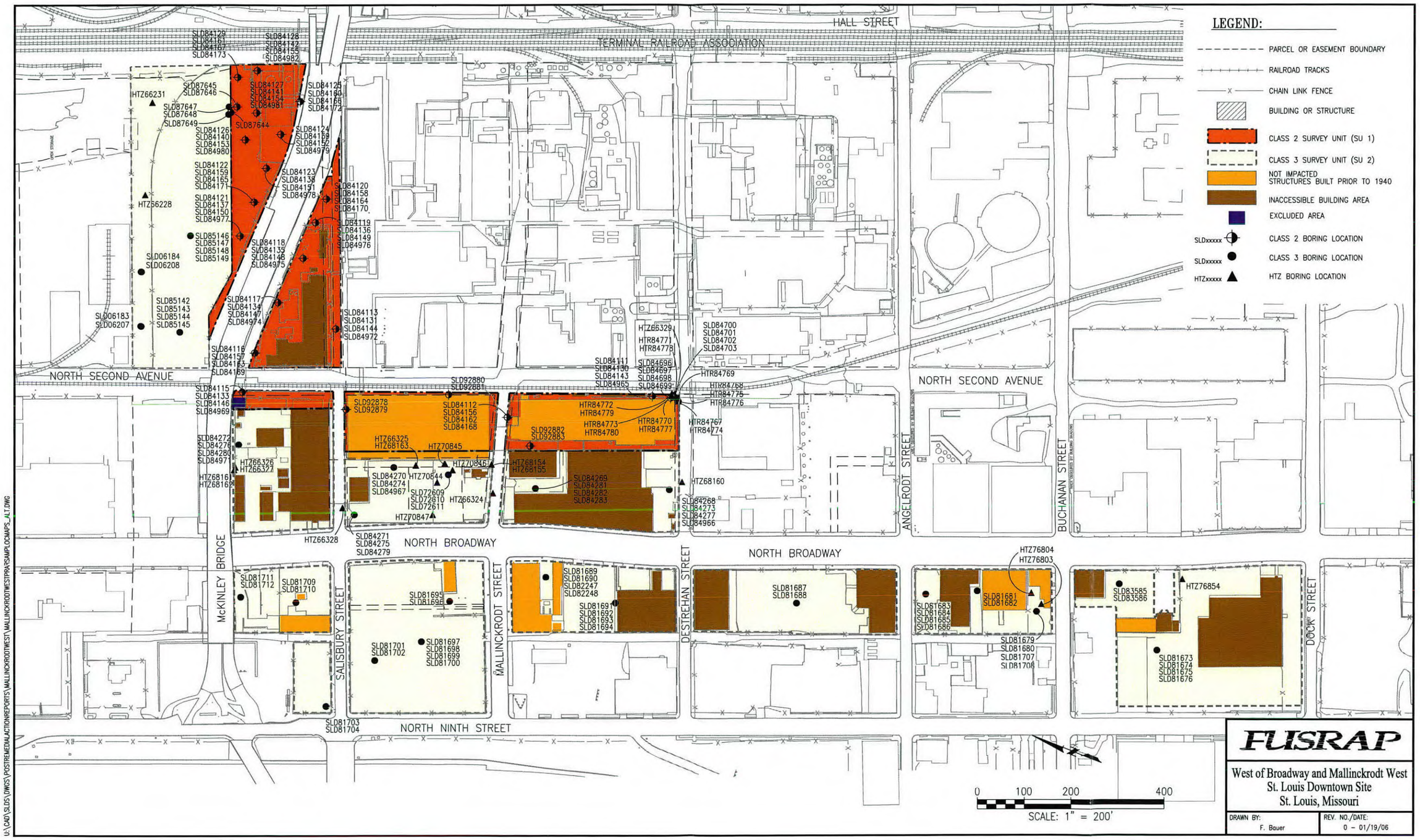

Figure 2. West of Broadway VPs and Mallinckrodt West Properties
Class 2 & Class 3 Sample Locations

2.0 SITE HISTORY AND DESCRIPTION

2.1 History

Mallinckrodt, Inc. has used, blended, and manufactured organic and inorganic chemicals since 1867. Mallinckrodt Chemical Works was contracted by MED and the AEC from 1942 until 1957 to process uranium (U) ore for the production of U metal. Residuals of the U metal production process, including spent pitchblende ore and process chemicals, were inadvertently released from the Mallinckrodt Property and into the environment through handling and disposal practices. Residuals from this process had elevated levels of Ra, thorium (Th), and U, and impacted surface and subsurface soils at a variety of properties within the SLDS.

In 1977, a radiological survey was conducted at the SLDS, and major radionuclides of interest, including Ra-226, Th-230, and U-238, were found in subsurface soils at levels significantly above background, to a maximum depth of approximately six feet. In response to this survey, it was determined that further investigation of the SLDS was necessary to characterize the nature and extent of contamination, in addition to possible actions to mitigate associated threats to human health and the environment.

Remedial actions at the SLDS are conducted under the Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was executed by the United States Department of Energy (DOE) in 1974 to identify, remediate, or otherwise control sites where residual radioactivity remains from operations conducted for the MED and AEC during the early years of the nation's atomic energy program (USACE 1998a).

2.2 Description

The West of Broadway VPs are the westernmost properties of the SLDS. The properties lie south of McKinley Bridge, north of Dock Street and are between Ninth Street to the west and Broadway to the east and include twelve VPs. Mallinckrodt Plants 3, 8, 9, 11 and Parking Lots are bounded on the north by the City of Venice VP (DT-11) and PSC Metals VP (DT-8) on the east by Terminal Railroad Association VP (DT-9), PSC Metals VP (DT-8) and Mallinckrodt Plants 1 and 2 on the south by Mallinckrodt Plant 10 and on the west by Broadway as shown on Figure 1. The surrounding area is largely a mixture of public, industrial, and commercial facilities with limited residential usage.

3.0 FSS UNITS

In accordance with MARSSIM guidance, the West of Broadway VPs and Mallinckrodt West properties were divided into Class 2 and Class 3 areas, resulting in one Class 2 area (i.e., SU-1) and one Class 3 area (i.e., SU-2). There were no areas identified as Class 1 areas.

3.1 Class 2 SU

In accordance with MARSSIM guidance, Class 2 SUs are limited in size (i.e., 10,000 m^2 + 10%). SU-1 consists of approximately 9,792 m^2. SU-1 consists of accessible soils exclusive of the area in the northeast corner of Plant 9 and inaccessible areas as shown in Figure 2. In addition to the systematic Class 2 surface samples needed to perform MARSSIM statistical tests, subsurface samples were collected in an effort to confirm that no unexpected subsurface contamination was present. Subsurface samples were typically collected at the 45-60 cm (1.5-2.0 ft) interval below ground surface (bgs), in accordance with the FSSP. These samples are referred to as "subsurface samples" in this report. Data from biased and subsurface samples were not included in MARSSIM statistical tests, per guidance found in MARSSIM (i.e., "judgment measurements are not included in the statistical evaluation of the SU because they violate the assumption of randomly selected, independent measurements. Instead, judgmental measurements are individually compared to the $DCGL_W$" [DOD 2000]). Biased and subsurface samples were included in evaluations of residual risk and dose.

3.2 Class 3 SU

In accordance with MARSSIM guidance, Class 3 SUs are unlimited in size. SU-2 consists of approximately 49,500 m^2. In addition to the randomly distributed Class 3 surface samples needed to perform MARSSIM statistical tests, subsurface samples were typically collected at 45-60 cm (1.5-2.0 ft) bgs, in an effort to confirm that no unexpected subsurface contamination was present. Guidance on the collection of subsurface samples is contained within the FSSP. Data from biased and subsurface samples were not included in MARSSIM statistical tests, but were included in evaluations of residual risk and dose.

3.3 Asphalt

The asphalt located on the West of Broadway VPs and Mallinckrodt West properties is un-impacted because there is no reasonable potential for residual contamination based on review of historical asphalt investigations described below. In addition, there were no layers of subsurface asphalt identified during sampling of SU-1 and SU-2 West of Broadway VPs and Mallinckrodt West properties.

The asphalt sampled within Mallinckrodt Plants 1 and 2 had the highest potential for contamination. Sampling indicated no contamination above the surface RGs (USACE 2004).

The investigation of the asphalt at Plant 1 and Plant 2 consisted of a gamma walkover survey and collection of 34 randomly distributed samples. The results of the investigation are summarized below.

Thirty-one of the 34 samples were consistent with background, two (SLD0682 and SLD0684) of the 34 samples in Plant 1 and 2 had activity above background (less than 5% of the surface RG) and one sample (SLD06079) was 50% of the surface RG. The SOR_N for the SU is less than 0.02. An analysis of the samples around SLD06079 shows minimal amounts of radioactivity in either the asphalt or the soil beneath the asphalt.

4.0 FSS MEASUREMENTS

Three types of measurements/samples were collected during the FSS to evaluate whether the property met RGs. These consisted of the elements listed below:

1. Surface gamma scans of accessible surface soils to identify locations within the property that exhibited elevated radioactivity.
2. Biased samples to investigate areas identified during the gamma scan.
3. Systematic Class 2 samples and randomly distributed Class 3 samples to obtain radionuclide concentrations across the property to the prescribed depth.

All of the measurements obtained were used to evaluate the property against RGs.

4.1 Surface Soil Gamma Scans

Gamma radiation scans (i.e., gamma walkover surveys) were performed over approximately 80% of the accessible Class 2 areas (SU-1) and 75% of the Class 3 areas (SU-2) using sodium iodide (NaI) radiation detection equipment coupled with a global positioning system. Electronic data could not be collected in all areas because satellite coverage was not available due to overhead obstructions (e.g., buildings). In these cases gamma walkover surveys were completed and the results were recorded manually. Text indicating the range of the results was added to the walkover map shown in Figure 3b. MARSSIM recommends that gamma radiation scans be performed on 10-100% of Class 2 areas and should be proportional to the potential for finding areas of elevated activity. Class 3 areas have the lowest potential for areas of elevated activity. MARSSIM guidance indicates that the survey coverage for a Class 3 area is based on professional judgment typically with 10% surveyed. The gamma walkover survey results are shown in Figures 3a -3c.

Upon completion of the gamma walkover survey, professional health physicists assessed the results of the survey and defined locations from which representative biased samples should be obtained. These areas typically were at least 2000 cpm above specific area background. Considerations included, but were not limited to, count rates, location relative to known contaminated areas, potential for residual radioactivity, existing radiological information in the area(s) of interest, isotopic distribution based on review of previous sampling events, and the variability and constituents making up background radiation in the area.

The ability to distinguish areas of elevated activity depends on background variability. Background variability is a function of both the constituents comprising the background media (e.g., soil, asphalt, concrete, brick, granite, coal, etc.) and the relative concentration of naturally occurring radionuclides within each media. Within the SLDS, variations in naturally occurring radiological background constituents result from the various materials (e.g., coal, slag, cinders, fly ash, etc) used as fill within the flood plain as well as from increased variability in K-40 concentrations. Each of these considerations affects the variability in count rate experienced when performing walkover surveys.

The gamma walkover survey indicates several areas with elevated count rates. The elevated count rates in most of these areas can be attributed to background variances caused by granite blocks, granite curb, or red bricks located in or near the area. The location of these materials is labeled on the gamma walkover survey Figures 3a, 3b and 3c. Areas affected by background variances caused by granite blocks, granite curb, or red bricks include:

- DT-20, DT-21, DT-22
- DT-24 and DT-25

first 15 cm (0.5 ft) of soil below the surface and 15 pCi/g averaged over 15 cm (0.5 ft) thick layers of soil more than 15 cm (0.5 ft) below the surface.

The ROD identifies 10 Code of Federal Regulation (CFR) 20 Subpart E as an ARAR. This standard is applicable to any NRC licensed material commingled with Manhattan Engineer District/Atomic Energy Commission (MED/AEC) contamination (USACE 1998a). This requirement provides standards for determining the extent to which accessible soils must be remediated before decommissioning of a site can be considered complete and the license terminated. The standard states that the residual dose for unrestricted use should not exceed 25 millirem per year (mrem/yr) total effective dose equivalent (TEDE) and that doses must be as low as reasonably achievable (ALARA).

The SOR_N calculations for surface (upper 15 cm or 0.5 ft) and subsurface (below 15 cm or 0.5 ft) soils are provided in the expressions below.

$$SOR_{N\text{-less than 15 cm}} = \frac{(\text{greater of } Th-230_N \text{ or } Ra-226_N)}{5\ pCi/g} + \frac{(\text{greater of } Th-232_N \text{ or } Ra-228_N)}{5\ pCi/g} + \frac{U-238_N}{50\ pCi/g}$$

$$SOR_{N\text{-greater than 15 cm}} = \frac{(\text{greater of } Th-230_N \text{ or } Ra-226_N)}{15\ pCi/g} + \frac{(\text{greater of } Th-232_N \text{ or } Ra-228_N)}{15\ pCi/g} + \frac{U-238_N}{50\ pCi/g}$$

A data quality assessment (DQA), which is a scientific and statistical evaluation that determines if property data are of the right type, quality, and quantity to support the intended use, is also presented in subsequent sections of this report. The DQA demonstrates that the SUs satisfied concentration-based RGs, risk and dose-based RGs, and statistical tests as outlined in the FSSP and supports releasing the SUs without restriction.

- DT-29 and DT-30
- Plant 3 and Plant 8

The gamma walkover survey indicates elevated count rates in the area between buildings located in DT-24 and DT-25. These elevated count rates were caused by building construction materials (granite blocks and red bricks) in combination with the narrow space between the buildings. Four random samples were obtained at one sample location (SLD81691) in the area between the buildings to assess the radiological status of the area. The sample results confirm that soils in the area are consistent with the background concentrations.

The gamma walkover survey indicates elevated count rates in the Mallinckrodt Parking Lots along the rail (north of Plant 11 and the McKinley Bridge). To assess the radiological status of this area and the nature of elevated count rates, two biased samples (HTZ66228 and HTZ66231) were collected in addition to four systematic samples at two other sample locations (SLD85142 and SLD06183). Biased sampling locations were selected after an evaluation of gamma walkover survey data (and other considerations discussed above) and are considered representative of all areas of elevated activity with the SU. These samples reflect concentrations that, although exhibiting SOR_N's up to 0.51, are typical of the background levels at SLDS. All accessible areas were walked over to provide added assurance that residual radionuclide concentrations left in place are consistent with background.

The gamma walkover survey indicates elevated count rates by the buildings located in DT-29 and DT-30. Two random samples were collected from one location (SLD83585) and one biased sample was collected (HTZ76854) from DT-29. Four random samples were obtained from one location (SLD81673) on DT-30. The sample results confirm that soils in the area are consistent with background concentrations. These elevated count rates were caused by building construction materials (red bricks) used in the buildings.

The gamma walkover survey indicates elevated count rates in the area by the buildings located in Plants 3 and 8. These elevated count rates were caused by construction materials (e.g., granite) used in the curbs. All accessible areas were walked over to provide added assurance that residual radionuclide concentrations left in place are consistent with background.

4.2 Field Instrument Detection Sensitivity

The field radiation detection survey instruments (and their functional and performance specifications) used during the surveys are listed in Table 1 below. Detection sensitivities were determined following the guidance of NUREG-1507 (NRC 1998) and are derived in the FSSP. The sensitivities presented were derived using typical instrument parameters and are well below the RG for soil, with the exception of Th-230. Since Ra-226 and Th-230 are commingled; Th-230 is detected through the presence of Ra-226.

Table 1. Radiological Field Survey Instruments

Description	Application	Detection Sensitivity[1]
Ludlum Model 2221 coupled with a Ludlum Model 44-10 (2-inch × 2-inch NaI gamma scintillation detector)	Gamma scans of all surfaces	Th-230 = 1120 pCi/g Ra-226 = 1.2 pCi/g U-natural = 40 pCi/g

[1] Minimum detectable concentrations (MDCs) shown in the table were calculated for areas without surface cover (i.e., rock asphalt, concrete, etc.) based on increased knowledge of site-specific parameters.
Note: Field instrumentation is calibrated annually.

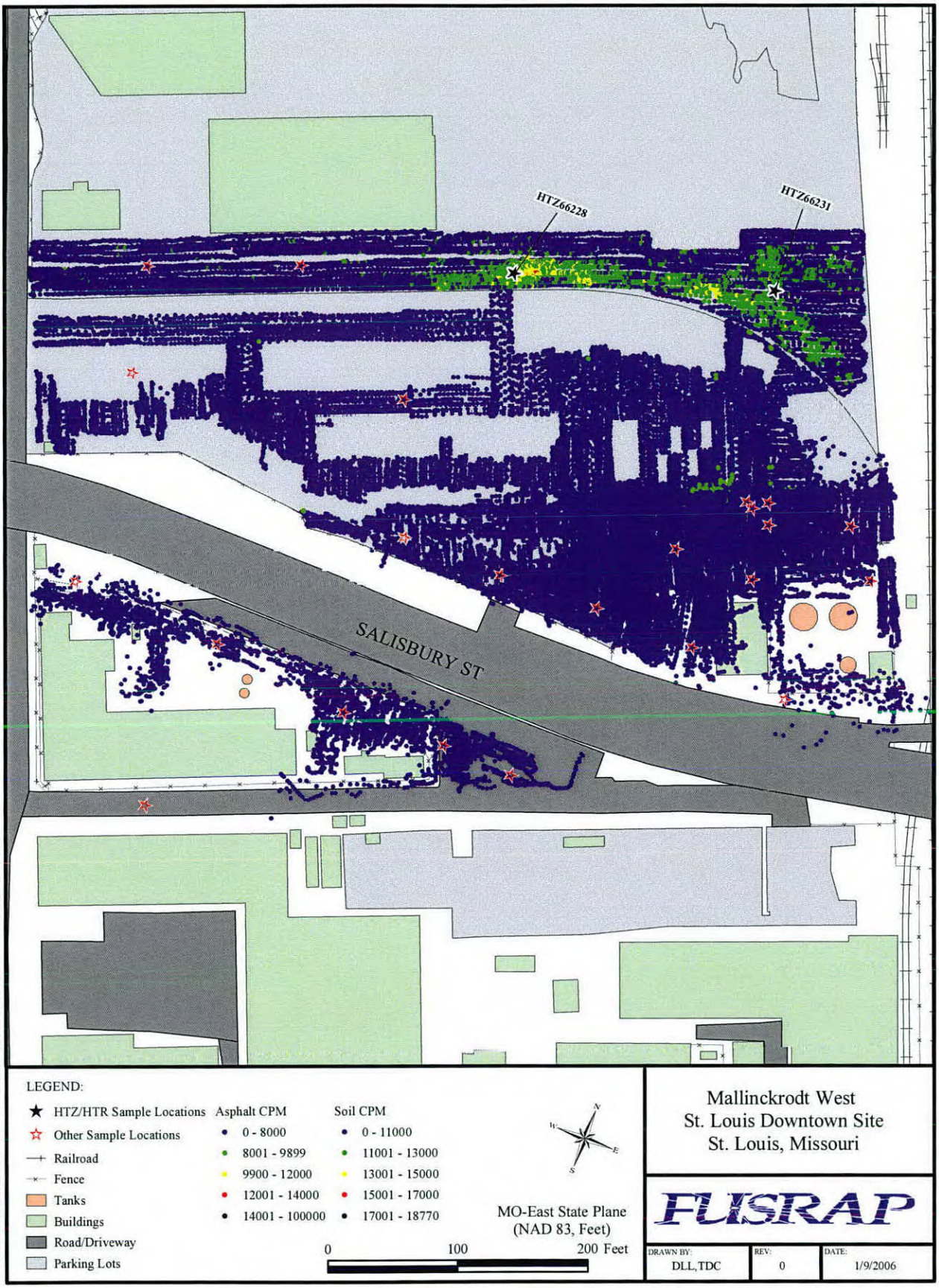

Figure 3a. West of Broadway VPs and Mallinckrodt West Properties Area 1 Gamma Walkover Survey

Figure 3b. West of Broadway and Mallinckrodt West Properties Area 2 Gamma Walkover Survey

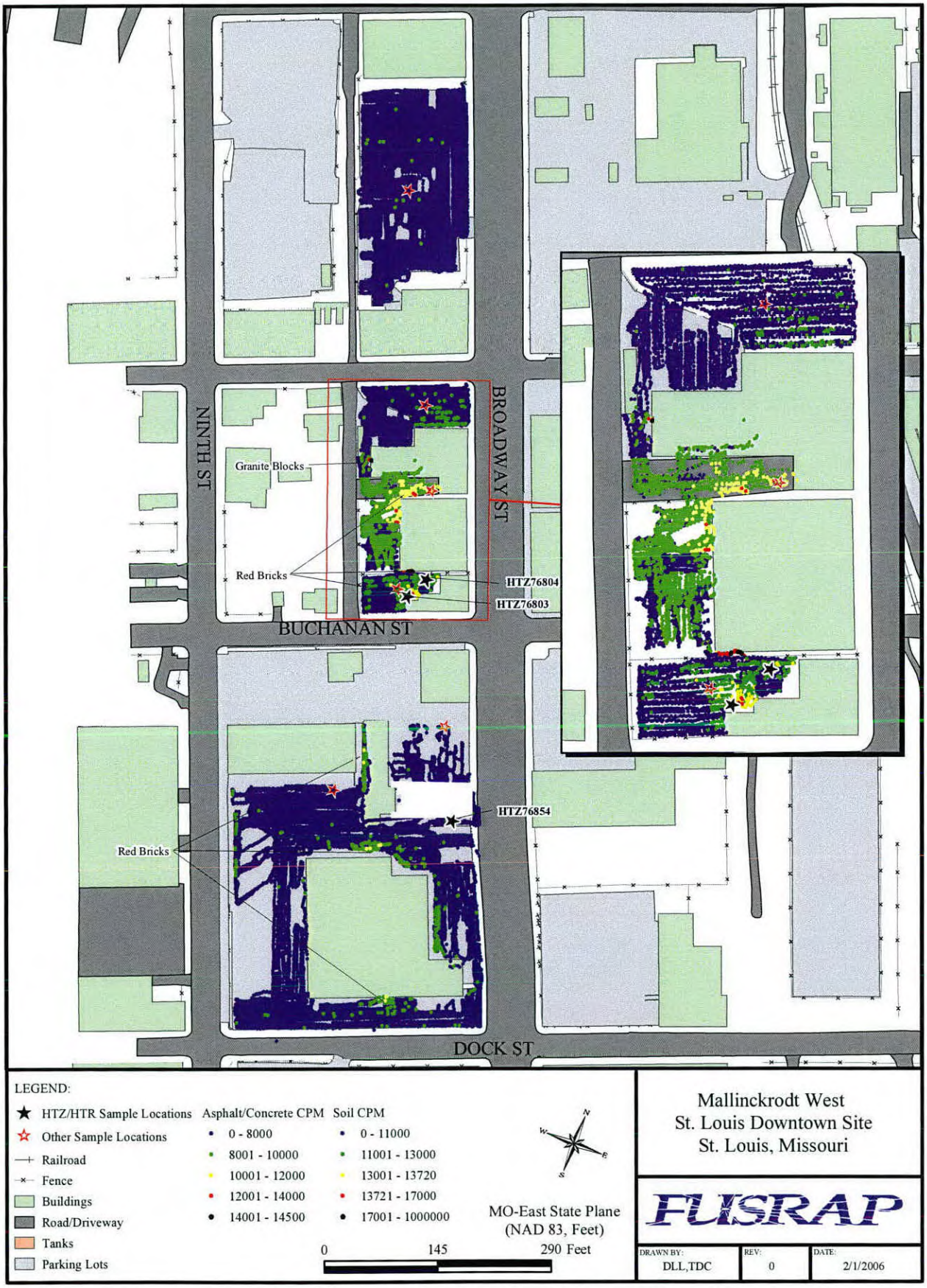

Figure 3c. West of Broadway and Mallinckrodt West Properties Area 3 Gamma Walkover Survey

4.3 Soil Samples

Biased soil samples were collected at locations that exhibited an elevated count rate nominally 2,000 cpm or greater above background for the specific area depending on isotopic ratios in the area of interest (i.e., historical reviews of scoping or characterization survey data) and background variability as determined during the gamma walkover survey. See Figures 3a-3c for sample locations.

FSS soil samples for SU-1, a Class 2 area, were collected in a systematic grid sample design. The sample design used for SU-2, a Class 3 area, was a randomly distributed sample design. The number and location of samples collected in the SUs were derived using MARSSIM guidance as described in the FSSP. The FSS incorporated the collection of soil samples in SUs on the surface (i.e. 15 cm or 0.5 feet) and typically at depth intervals of 45-60 cm (1.5-2.0 ft). Sample borings at both Class 2 and Class 3 locations were scanned to verify that subsurface pockets of contamination did not exist. (USACE 2000a). Soil samples were collected at 45-60 cm (1.5-2.0 ft) depth intervals unless scanning indicated elevated contamination levels in other locations of the boring. In general, one surface sample and one subsurface sample were collected at each location. The sampling included the following listed elements:

- In SU-1, a sample was collected from an interval within the upper 15 cm (0.5 ft) of soil at all sampling locations. The samples were collected within the top 15 cm (0.5 ft) below the ground surface or below ground cover material (e.g., asphalt) regardless of thickness, as applicable. These samples were conservatively evaluated using surface RGs. Results of the surface soil data are presented in Table 2. At least one subsurface sample was taken from each sample location from the initial 0-60 cm (0-2.0 ft) soil column, from the 15 cm (0.5 ft) area exhibiting the highest radioactivity. If the soil column had a uniform count rate the deepest 15 cm (0.5 ft) was sampled. Per the FFSP, one-third of the sample locations were required to be sampled by removing soil columns of approximately 45-60 cm (1.5-2.0 ft) in length until a total depth of 1.8 m (6 ft) bgs was reached (USACE 20002a). In compliance with the one-third minimum requirement, eighteen of the 21 sample locations in SU-1 were sampled to a depth of 1.8 m (6 ft). Results for Class 2 subsurface samples are presented in Table 3. Each of the SU-1 samples collected was subjected to laboratory analysis. The SU-1 sampling results were compared to ROD RGs as discussed in Section 6.2.
- In SU-2, a sample was collected from an interval within the upper 15 cm (0.5 ft) of soil at all sampling locations. The samples were collected within the top 15 cm (0.5 ft) bgs or below ground cover material (e.g., asphalt) regardless of thickness as applicable. These samples were conservatively evaluated using surface RGs. Results of the surface soil data are presented in Table 4. At least one additional subsurface sample was taken from each sample location from the initial 0-60 cm (0-2.0 ft) soil column, from the 15 cm (0.5 ft) area exhibiting the highest radioactivity. If the soil column had a uniform count rate the deepest 15 cm (0.5 ft) was sampled. In addition, one-third of the sample locations were sampled by removing soil columns of approximately 45-60 cm (1.5-2.0 ft) in length until a total depth of 1.8 m (6 ft) bgs was reached (USACE 20002a). SLD81676, SLD81686, SLD81708, SLD82248, SLD84269, SLD84966, SLD84967, SLD84971, SLD85142 and SLD85146 were sampled to a depth of 1.8 m (6 ft). Results for Class 3 subsurface samples are presented in Table 5. Each of the SU-2 samples collected was subjected to laboratory analysis. The SU-2 sampling results were compared to ROD RGs as discussed in Section 6.2.

The Class 2 (SU-1) area of Plant 8 is almost completely inaccessible due to the presence of buildings and active rail lines. To best represent the property conditions at the Class 2 area of Plant 8, two systematic samples were obtained in Plant 8 (SLD92878, SLD92880) and one systematic sample was obtained in Plant 3 (SLD92882) as close as practicable to the inaccessible locations.

Biased samples were collected in areas that had elevated activity as indicated during the gamma walkover surveys. Consistent with MARSSIM, investigation levels for samples in Class 2 and 3 areas are the $DCGL_W$ and 0.5 of the $DCGL_W$, respectively. Biased samples were collected within the upper 15 cm (0.5 ft) of the surface soil. Also, biased subsurface samples were collected at some locations based on the radiological screen of the surface sample. These samples were compared to subsurface RGs. The results for the biased surface samples are presented in Table 2 and Table 4. Biased subsurface results are presented in Table 3 and Table 5. Each of the biased samples collected were subjected to laboratory analysis.

Table 2. SU-1 Class 2 and Biased Surface Soil Data Summary

Reference Area Data Summary

Statistic	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Th-232 (pCi/g)	Ra-228 (pCi/g)	Th-228 (pCi/g)	Ac-227 (pCi/g)	Pa-231 (pCi/g)	SOR_B (5/5/50)	SOR_B (15/15/50)
Mean	2.78	1.94	1.44	0.09	1.09	0.95	1.16	0.14	0.89	0.82	0.29
Median	2.53	1.66	1.16	0.08	1.07	0.97	1.10	0.11	0.98	0.76	0.27
UCL-95	3.04	2.18	1.67	0.12	1.18	1.00	1.26	0.18	1.12	-	-
St. Dev	0.89	0.76	0.75	0.08	0.29	0.17	0.35	0.14	0.76	0.21	0.08
Range	3.93	3.19	3.19	0.33	1.25	0.82	1.59	0.80	2.55	0.95	0.35
Detects	32	32	32	0	32	32	32	7	13	-	-
No. Samples	32	32	32	32	32	32	32	32	32	32	32

SU-1 Class 2 and Biased Surface Soil Data Summary

Statistic	Sample Type	Ra-226	Th-230	U-238	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231	SOR_G	SOR_N
Mean	Systematic	1.52	1.46	1.59	0.07	0.44	0.41	0.59	0.01	0.07	0.45	0.02
Median	Systematic	1.36	1.39	1.27	0.05	0.30	0.34	0.49	0.00	0.03	0.44	0.00
Standard Deviation	Systematic	0.70	0.63	1.10	0.20	0.33	0.28	0.32	0.10	0.25	0.21	0.08
Number of samples	Systematic	21	21	21	21	21	21	21	21	21	21	21
Maximum	All	6.62	17.30	7.19	0.82	6.02	6.36	8.18	0.68	1.26	4.05	3.45
Range	All	6.09	16.70	6.69	0.82	5.98	6.33	7.96	0.68	1.26	3.90	3.45

Sample ID	Sample Type	Ra-226	Th-230	U-238	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231	SOR_G	SOR_N
SLD84111	Systematic	1.62	0.98	1.19	-0.04	0.38	0.34	0.30	-0.06	-0.09	0.43	0.00
SLD84112	Systematic	0.89	0.89	0.70	0.02	0.10	0.18	0.43	0.04	-0.03	0.23	0.00
SLD84113	Systematic	2.10	1.39	2.06	-0.05	0.80	0.67	0.58	-0.07	0.43	0.62	0.01
SLD84115	Systematic	3.63	3.38	5.51	0.82	0.62	0.96	1.44	0.26	0.38	1.03	0.37
SLD84116	Systematic	1.41	1.43	1.36	0.15	0.64	0.46	0.91	-0.16	0.31	0.44	0.00
SLD84117	Systematic	0.64	0.60	0.63	0.17	0.05	0.08	0.28	0.02	0.10	0.16	0.00
SLD84118	Systematic	1.03	1.11	0.72	0.04	0.16	0.16	0.26	0.08	-0.31	0.27	0.00
SLD84119	Systematic	2.31	2.11	2.69	0.03	0.84	0.76	0.93	-0.03	0.33	0.68	0.06
SLD84120	Systematic	1.83	1.97	1.89	0.05	1.06	0.68	1.10	-0.09	0.28	0.64	0.01
SLD84121	Systematic	0.97	1.16	1.13	-0.30	0.29	0.34	0.49	0.00	-0.46	0.32	0.00
SLD84122	Systematic	1.06	1.07	0.65	0.07	0.20	0.16	0.26	-0.02	-0.08	0.27	0.00
SLD84123	Systematic	1.82	1.56	1.86	0.10	0.47	0.52	0.63	0.04	0.25	0.50	0.01
SLD84124	Systematic	1.27	1.18	0.94	0.07	0.28	0.19	0.49	0.00	0.01	0.33	0.00
SLD84125	Systematic	1.12	1.00	1.10	0.05	0.11	0.19	0.49	-0.08	0.15	0.28	0.00
SLD84126	Systematic	1.90	1.77	1.27	0.01	0.21	0.30	0.76	0.03	0.36	0.46	0.00
SLD84127	Systematic	1.36	1.93	2.24	-0.01	0.30	0.28	0.51	0.00	0.22	0.49	0.02
SLD84128	Systematic	1.30	1.94	1.00	0.07	0.12	0.10	0.33	-0.07	-0.02	0.43	0.00
SLD84129	Systematic	0.53	0.68	0.50	-0.07	0.04	0.03	0.22	-0.05	0.03	0.15	0.00
SLD92878	Systematic	2.38	1.94	1.87	0.08	1.05	0.90	0.66	0.21	0.00	0.72	0.01
SLD92880	Systematic	1.47	1.60	2.19	0.08	0.52	0.59	0.89	0.18	-0.27	0.48	0.02
SLD92882	Systematic	1.28	0.99	1.92	0.08	0.91	0.62	0.49	-0.08	-0.15	0.48	0.01
HTR84767	Biased	1.46	3.36	1.35	0.05	0.67	0.35	0.70	0.14	0.35	0.83	0.28
HTR84768	Biased	1.98	14.30	2.63	0.32	1.18	0.49	0.90	0.24	0.33	3.15	2.51
HTR84769	Biased	1.33	3.57	1.66	0.13	0.74	0.38	0.40	0.06	0.26	0.90	0.33
HTR84770	Biased	3.36	7.13	4.93	0.44	1.04	0.75	1.47	0.28	0.84	1.73	1.11
HTR84771	Biased	2.47	3.06	2.94	0.14	1.37	0.69	1.60	0.04	0.09	0.94	0.31
HTR84772	Biased	6.62	7.88	5.05	0.10	6.02	6.36	8.18	0.02	1.26	2.95	2.34
HTR84773	Biased	2.19	4.37	2.21	0.30	0.75	0.75	0.79	0.05	0.52	1.07	0.50
HTZ66329	Biased	4.11	17.30	7.19	0.56	1.90	2.25	2.45	0.68	-0.07	4.05	3.45
SLD84696	Biased	4.70	3.69	5.72	0.47	0.66	0.56	1.09	0.36	0.59	1.19	0.47
SLD84700	Biased	5.19	5.20	6.66	0.56	1.72	1.90	2.11	0.40	0.18	1.55	0.95

Notes:

SOR_B = sum of ratio for the background soils.

Results are expressed in pCi/g; SOR values are unitless.

Protactinium 231 (Pa-231), Actinium 227 (Ac-227)

Table 3. SU-1 Class 2 and Biased Subsurface Soil Data Summary

Reference Area Data Summary											
Statistic	Ra-226 (pCi/g)	Th-230 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Th-232 (pCi/g)	Ra-228 (pCi/g)	Th-228 (pCi/g)	Ac-227 (pCi/g)	Pa-231 (pCi/g)	SOR_B (5/5/50)	SOR_B (15/15/50)
Mean	2.78	1.94	1.44	0.09	1.09	0.95	1.16	0.14	0.89	0.82	0.29
Median	2.53	1.66	1.16	0.08	1.07	0.97	1.10	0.11	0.98	0.76	0.27
UCL-95	3.04	2.18	1.67	0.12	1.18	1.00	1.26	0.18	1.12	-	-
St. Dev	0.89	0.76	0.75	0.08	0.29	0.17	0.35	0.14	0.76	0.21	0.08
Range	3.93	3.19	3.19	0.33	1.25	0.82	1.59	0.80	2.55	0.95	0.35
Detects	32	32	32	0	32	32	32	7	13	-	-
No. Samples	32	32	32	32	32	32	32	32	32	32	32

SU-1 Class 2 and Biased Subsurface Soil Data Summary											
Statistic	Ra-226	Th-230	U-238	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231	SOR_G	SOR_N
Mean	2.08	2.44	2.13	0.11	0.79	0.80	1.02	0.03	0.09	0.28	0.08
Median	1.71	1.95	1.85	0.10	0.72	0.80	0.98	0.01	0.09	0.24	0.02
Standard Deviation	0.98	2.41	1.30	0.19	0.41	0.33	0.45	0.20	0.58	0.18	0.17
Number of samples	73	73	73	73	73	73	73	73	73	73	73
Maximum	5.05	19.40	8.24	0.69	1.74	1.77	2.11	0.68	1.92	1.43	1.23
Range	4.36	18.63	7.86	0.69	1.70	1.60	2.01	0.68	1.92	1.33	1.23

Sample ID	Station ID	Ra-226	Th-230	U-238	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231	SOR_G	SOR_N
SLD84130	SLD84111	3.85	4.93	5.97	0.66	0.47	0.77	1.23	0.21	-0.19	0.50	0.29
SLD84143	SLD84111	1.22	1.82	0.73	0.05	0.24	0.21	0.48	0.04	-0.07	0.15	0.00
SLD84965	SLD84111	2.29	1.78	2.48	0.30	0.84	1.32	1.39	0.45	1.61	0.29	0.05
SLD84156	SLD84112	1.43	1.16	2.43	0.18	1.07	0.98	1.26	-0.24	0.27	0.22	0.02
SLD84162	SLD84112	2.09	2.02	1.43	-0.12	1.73	1.51	1.48	-0.44	-0.57	0.28	0.05
SLD84168	SLD84112	1.74	1.79	2.02	0.46	1.74	1.70	1.98	-0.08	-0.56	0.28	0.06
SLD84131	SLD84113	1.01	1.17	0.68	0.05	0.11	0.16	0.40	-0.04	0.08	0.10	0.00
SLD84144	SLD84113	1.19	0.77	0.73	0.11	0.04	0.29	0.10	-0.05	0.12	0.11	0.00
SLD84972	SLD84113	1.33	1.36	0.97	0.03	0.50	0.50	0.88	0.04	-0.04	0.14	0.00
SLD84133	SLD84115	2.22	2.56	1.85	-0.08	0.79	0.82	0.93	-0.06	-0.16	0.26	0.05
SLD84146	SLD84115	1.71	1.57	0.66	0.14	0.81	0.80	0.62	0.01	-0.42	0.18	0.00
SLD84969	SLD84115	1.41	2.23	1.80	0.03	0.92	1.26	1.78	-0.08	0.02	0.27	0.05
SLD84157	SLD84116	1.31	1.95	1.18	0.05	0.77	0.87	1.25	0.01	0.34	0.21	0.00
SLD84163	SLD84116	1.35	0.94	1.34	0.07	0.62	0.87	1.47	0.16	0.24	0.17	0.00
SLD84169	SLD84116	1.45	1.91	1.70	-0.37	1.35	1.21	1.09	-0.12	0.39	0.25	0.02
SLD84134	SLD84117	1.55	1.17	1.92	0.22	0.66	0.96	0.85	0.02	0.03	0.21	0.01
SLD84147	SLD84117	1.51	1.33	0.94	0.16	1.38	0.81	1.41	-0.17	0.05	0.21	0.02
SLD84974	SLD84117	3.47	2.84	2.49	0.14	0.58	0.46	0.46	0.05	0.07	0.32	0.08
SLD84135	SLD84118	2.36	1.16	2.00	0.18	0.37	0.85	0.91	-0.18	0.25	0.25	0.01
SLD84148	SLD84118	1.52	0.95	1.51	-0.05	0.68	0.62	0.68	0.07	-0.22	0.18	0.00
SLD84975	SLD84118	3.34	2.66	3.37	0.32	1.51	1.63	1.46	0.23	0.06	0.40	0.13
SLD84136	SLD84119	1.19	2.29	1.04	0.22	0.65	0.58	0.96	-0.03	-0.12	0.22	0.02
SLD84149	SLD84119	4.89	2.60	3.08	-0.25	0.87	1.28	1.47	-0.32	0.29	0.47	0.20
SLD84976	SLD84119	2.33	2.13	1.75	-0.02	0.84	0.85	1.24	0.21	-0.57	0.25	0.02
SLD84158	SLD84120	1.11	0.95	1.03	-0.07	0.18	0.39	0.99	0.00	0.06	0.12	0.00
SLD84164	SLD84120	1.42	1.71	1.35	-0.07	0.81	0.73	0.86	0.02	-0.22	0.19	0.00
SLD84170	SLD84120	1.40	1.64	1.56	-0.02	0.82	0.94	1.06	-0.10	-0.17	0.20	0.00
SLD84137	SLD84121	2.91	2.74	3.08	0.27	1.32	1.07	1.48	-0.18	-0.43	0.34	0.10
SLD84150	SLD84121	1.61	1.75	2.95	0.04	1.11	1.11	1.16	-0.17	1.92	0.25	0.04
SLD84977	SLD84121	1.20	1.73	0.91	0.17	0.87	0.93	1.55	-0.12	0.81	0.20	0.00
SLD84159	SLD84122	1.34	1.21	1.14	0.09	0.41	0.48	0.69	0.16	-0.46	0.14	0.00
SLD84165	SLD84122	1.76	2.12	1.75	-0.26	1.37	1.04	1.28	-0.02	0.33	0.27	0.04
SLD84171	SLD84122	1.95	1.81	0.77	0.02	0.96	0.99	1.16	0.13	-1.64	0.21	0.00

Table 3. SU-1 Class 2 and Biased Subsurface Soil Data Summary (Cont'd)

Sample ID	Sample Type	[Ra-226]	[Th-230]	[U-238]	[U-235]	[Th-232]	[Ra-228]	[Th-228]	[Ac-227]	[Pa-231]	SOR_C	SOR_N
SLD84138	SLD84123	2.67	2.12	2.46	0.69	0.67	0.95	0.64	0.12	0.65	0.29	0.03
SLD84151	SLD84123	2.30	2.05	2.87	0.05	0.46	0.74	0.73	0.23	-0.85	0.26	0.04
SLD84978	SLD84123	1.66	1.33	0.38	-0.24	1.28	0.92	1.00	-0.01	0.09	0.20	0.01
SLD84139	SLD84124	3.35	3.11	2.85	0.40	0.65	0.69	0.75	0.04	0.20	0.33	0.11
SLD84152	SLD84124	1.19	1.18	1.40	0.16	1.03	0.92	1.87	-0.01	0.22	0.18	0.00
SLD84979	SLD84124	1.99	1.65	1.65	0.08	0.55	0.77	0.51	-0.07	0.09	0.22	0.00
SLD84160	SLD84125	1.43	0.97	2.04	0.13	0.17	0.53	0.65	-0.14	0.53	0.17	0.01
SLD84166	SLD84125	3.83	3.28	3.59	0.03	0.97	1.19	1.71	0.15	0.39	0.41	0.15
SLD84172	SLD84125	1.89	1.95	0.67	-0.25	1.14	1.13	0.98	0.09	0.26	0.22	0.01
SLD84140	SLD84126	2.58	2.70	2.34	0.02	0.72	0.90	1.05	0.03	0.09	0.29	0.07
SLD84153	SLD84126	1.70	2.30	1.60	0.35	0.28	0.38	0.56	-0.03	0.07	0.21	0.03
SLD84980	SLD84126	1.65	1.41	1.41	-0.22	0.58	0.52	0.47	-0.11	-0.05	0.18	0.00
SLD84141	SLD84127	1.39	0.96	2.33	0.15	0.27	0.56	0.66	-0.17	0.07	0.18	0.02
SLD84154	SLD84127	0.69	1.78	1.28	0.23	0.65	0.49	0.38	-0.23	-0.16	0.19	0.00
SLD84981	SLD84127	1.48	1.75	1.57	-0.19	0.85	0.91	1.41	-0.17	0.82	0.21	0.00
SLD84142	SLD84128	1.97	2.75	2.00	0.28	0.62	0.30	0.38	0.16	-0.03	0.26	0.07
SLD84155	SLD84128	2.28	2.57	2.36	0.16	0.37	0.85	1.08	0.18	-0.21	0.28	0.06
SLD84982	SLD84128	2.21	2.19	1.81	0.18	0.77	0.53	0.74	0.02	0.09	0.23	0.02
SLD84161	SLD84129	4.93	3.32	2.08	0.10	1.34	1.77	1.81	-0.53	-1.44	0.49	0.21
SLD84167	SLD84129	2.00	1.70	2.38	0.27	0.88	0.67	1.09	0.08	-1.81	0.24	0.02
SLD84173	SLD84129	1.33	1.45	1.51	0.05	0.55	0.85	0.87	0.01	0.35	0.18	0.00
SLD84697	SLD84696	2.68	1.79	2.29	0.11	1.17	0.76	1.62	-0.04	-0.40	0.30	0.02
SLD84698	SLD84696	1.26	5.20	1.44	0.28	1.72	0.71	2.11	-0.01	-0.10	0.49	0.26
SLD84699	SLD84696	1.26	2.38	1.42	0.08	0.43	0.76	0.78	-0.04	0.09	0.24	0.03
SLD84701	SLD84700	1.94	1.30	3.68	0.42	0.99	0.52	0.81	0.28	0.45	0.27	0.04
SLD84702	SLD84700	1.19	1.54	1.74	0.15	0.40	0.41	0.40	-0.08	-0.09	0.17	0.01
SLD84703	SLD84700	1.21	2.05	1.82	0.10	0.33	0.87	0.68	0.00	0.31	0.23	0.01
SLD87644	SLD87644	3.69	2.81	3.10	0.03	1.53	1.32	1.28	0.00	0.60	0.41	0.12
SLD87645	SLD87645	5.05	4.05	5.30	0.41	1.22	0.86	1.61	0.68	0.79	0.52	0.24
SLD87646	SLD87645	3.76	3.25	2.36	0.07	1.32	0.84	1.76	0.02	0.21	0.39	0.12
SLD92879	SLD92878	3.18	2.67	1.99	0.09	0.74	0.61	0.88	0.14	0.22	0.30	0.06
SLD92881	SLD92880	1.34	1.60	2.36	0.09	0.59	0.54	0.57	0.21	0.17	0.19	0.02
SLD92883	SLD92882	1.07	1.43	0.75	0.02	1.36	0.80	1.55	-0.01	0.35	0.20	0.02
HTR84774	HTR84767	1.36	2.06	1.95	0.10	0.29	0.38	0.77	-0.09	0.21	0.20	0.02
HTR84775	HTR84768	3.33	19.40	4.74	0.27	0.70	0.56	0.64	0.49	0.68	1.43	1.23
HTR84776	HTR84768	3.04	10.30	4.40	0.18	0.32	0.61	0.63	0.47	0.47	0.82	0.62
HTR84777	HTR84770	2.86	2.62	8.24	0.00	0.55	0.87	1.13	0.04	1.45	0.41	0.18
HTR84778	HTR84771	2.10	2.77	1.97	0.02	0.60	0.58	1.07	0.01	0.15	0.26	0.07
HTR84779	HTR84772	1.67	2.28	2.99	0.23	0.56	0.50	0.44	0.52	0.61	0.25	0.05
HTR84780	HTR84773	2.73	5.39	3.75	0.25	0.65	0.58	0.62	0.37	0.15	0.48	0.28

Notes:
SOR_B = sum of ratio for the background soils.
Results are expressed in pCi/g; SOR values are unitless.
Protactinium 231 (Pa-231), Actinium 227 (Ac-227)

Table 4. SU-2 Class 3 and Biased Surface Soil Data Summary

Reference Area Data Summary											
Statistic	**Ra-226 (pCi/g)**	**Th-230 (pCi/g)**	**U-238 (pCi/g)**	**U-235 (pCi/g)**	**Th-232 (pCi/g)**	**Ra-228 (pCi/g)**	**Th-228 (pCi/g)**	**Ac-227 (pCi/g)**	**Pa-231 (pCi/g)**	**SOR_B (5/5/50)**	**SOR_B (15/15/50)**
Mean	2.78	1.94	1.44	0.09	1.09	0.95	1.16	0.14	0.89	0.82	0.29
Median	2.53	1.66	1.16	0.08	1.07	0.97	1.10	0.11	0.98	0.76	0.27
UCL-95	3.04	2.18	1.67	0.12	1.18	1.00	1.26	0.18	1.12	-	-
St. Dev	0.89	0.76	0.75	0.08	0.29	0.17	0.35	0.14	0.76	0.21	0.08
Range	3.93	3.19	3.19	0.33	1.25	0.82	1.59	0.80	2.55	0.95	0.35
Detects	32	32	32	0	32	32	32	7	13	-	-
No. Samples	32	32	32	32	32	32	32	32	32	32	32

SU-2 Class 3 and Biased Surface Soil Data Summary											
Statistic	**Sample Type**	**Ra-226**	**Th-230**	**U-238**	**U-235**	**Th-232**	**Ra-228**	**Th-228**	**Ac-227**	**Pa-231**	**SOR_G**	**SOR_N**
Mean	Random	1.66	1.83	1.60	0.09	0.77	0.65	0.92	0.02	0.04	0.58	0.06
Median	Random	1.35	1.88	1.47	0.11	0.79	0.71	0.90	0.02	0.04	0.62	0.02
Standard Deviation	Random	0.77	0.72	0.91	0.19	0.39	0.31	0.40	0.12	0.25	0.22	0.10
Number of samples	Random	24	24	24	24	24	24	24	24	24	24	24
Maximum	All	6.28	5.46	5.60	0.57	1.84	1.31	1.98	0.66	0.95	1.61	0.84
Range	All	5.92	4.72	5.32	0.57	1.80	1.24	1.70	0.66	0.95	1.40	0.84

SampleID	Sample Type	Ra-226	Th-230	U-238	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231	SOR_G	SOR_N
SLD06183	Random	1.90	2.70	2.34	0.20	0.66	0.76	0.86	0.10	-0.06	0.74	0.17
SLD06184	Random	2.94	3.47	4.25	0.28	1.23	0.83	1.45	0.04	-0.02	1.02	0.39
SLD72609	Random	2.38	1.93	2.08	0.22	1.09	0.94	1.13	0.12	0.04	0.74	0.01
SLD81673	Random	1.04	0.74	1.14	0.06	0.49	0.46	0.59	0.03	-0.04	0.33	0.00
SLD81679	Random	3.78	3.13	3.32	0.48	0.97	0.81	1.34	0.15	-0.78	1.02	0.27
SLD81681	Random	1.19	0.95	1.67	-0.06	0.50	0.42	0.54	-0.09	-0.06	0.37	0.00
SLD81683	Random	1.57	2.11	2.19	0.21	1.10	0.80	0.93	0.10	-0.08	0.69	0.05
SLD81687	Random	1.28	2.01	1.66	0.11	0.93	0.99	1.19	-0.02	0.32	0.63	0.03
SLD81689	Random	1.34	2.38	1.41	0.16	0.72	0.68	1.07	-0.08	0.06	0.65	0.09
SLD81691	Random	0.90	1.24	1.18	0.15	1.17	0.65	0.53	-0.02	0.05	0.51	0.02
SLD81695	Random	1.35	2.06	1.54	0.14	0.80	0.78	1.29	0.18	0.21	0.60	0.03
SLD81697	Random	1.03	1.38	0.97	0.11	1.06	0.62	0.59	-0.02	-0.04	0.51	0.00
SLD81701	Random	1.18	1.58	1.04	-0.02	0.61	0.59	0.66	-0.04	0.16	0.46	0.00
SLD81703	Random	0.72	0.74	0.47	0.04	0.26	0.11	0.39	-0.04	0.15	0.21	0.00
SLD81709	Random	1.14	1.27	1.32	0.04	0.66	0.60	0.84	0.09	-0.02	0.41	0.00
SLD81711	Random	1.83	2.26	1.85	0.02	0.78	0.79	1.33	0.10	0.24	0.65	0.07
SLD83585	Random	2.15	2.40	2.07	0.21	0.92	0.75	1.12	0.04	0.08	0.70	0.10
SLD84268	Random	2.62	2.50	2.46	0.21	1.07	1.07	1.17	-0.06	0.63	0.79	0.16
SLD84269	Random	2.20	1.78	0.38	-0.61	1.48	1.31	1.58	-0.35	0.18	0.74	0.08
SLD84270	Random	0.95	1.26	0.68	0.08	0.17	0.20	0.28	-0.08	-0.02	0.30	0.00
SLD84271	Random	2.06	1.87	1.26	-0.11	1.24	0.76	0.66	0.25	-0.32	0.69	0.03
SLD84272	Random	2.26	1.90	1.89	0.15	0.39	0.49	0.54	0.08	0.05	0.59	0.01
SLD85142	Random	1.05	1.06	0.69	0.02	0.04	0.07	0.46	0.01	0.14	0.24	0.00
SLD85146	Random	0.88	1.21	0.51	-0.03	0.12	0.09	1.63	-0.03	0.01	0.28	0.00
HTZ66228	Biased	3.30	3.60	3.51	0.33	1.44	0.81	1.52	0.06	0.09	1.08	0.44
HTZ66231	Biased	2.52	4.38	2.66	0.24	0.93	0.68	0.75	0.12	0.46	1.12	0.51
HTZ66324	Biased	2.10	3.11	2.22	0.16	1.15	0.85	1.92	0.14	0.30	0.90	0.26
HTZ66325	Biased	0.37	0.96	0.28	0.03	0.37	0.35	0.37	0.12	0.12	0.27	0.00
HTZ66326	Biased	2.63	3.51	5.60	0.34	0.93	1.02	1.65	0.15	0.62	1.02	0.41
HTZ66328	Biased	0.36	1.41	0.49	0.02	1.84	0.23	1.98	0.04	-0.22	0.66	0.15
HTZ68160	Biased	2.68	4.87	2.24	0.20	0.63	0.51	0.97	0.23	0.16	1.14	0.60
HTZ68161	Biased	3.03	4.35	3.65	0.25	0.72	0.91	1.29	0.66	0.74	1.13	0.53
HTZ70844	Biased	5.62	4.69	3.07	0.57	1.13	1.17	1.27	0.24	0.34	1.42	0.64
HTZ70845	Biased	3.59	4.39	2.57	0.18	1.02	0.80	1.55	0.27	0.28	1.13	0.51
HTZ70846	Biased	6.28	5.46	4.54	0.49	1.08	1.30	1.98	0.35	0.42	1.61	0.84
HTZ70847	Biased	1.24	0.80	0.91	-0.08	1.15	0.64	0.89	0.07	-0.12	0.50	0.01
HTZ76803	Biased	3.81	3.33	3.47	0.19	1.43	1.15	1.20	0.33	0.26	1.12	0.39
HTZ76804	Biased	1.17	1.74	1.13	0.12	0.28	0.44	0.48	0.11	0.95	0.46	0.00
HTZ76854	Biased	1.04	1.12	4.72	0.33	0.37	0.43	0.73	-0.03	0.06	0.40	0.07

Notes:

SOR_B = sum of ratio for the background soils.

Results are expressed in pCi/g; SOR values are unitless.

Protactinium 231 (Pa-231), Actinium 227 (Ac-227)

Table 5. SU-2 Class 3 and Biased Subsurface Soil Data Summary

Reference Area Data Summary											
Statistic	**Ra-226 (pCi/g)**	**Th-230 (pCi/g)**	**U-238 (pCi/g)**	**U-235 (pCi/g)**	**Th-232 (pCi/g)**	**Ra-228 (pCi/g)**	**Th-228 (pCi/g)**	**Ac-227 (pCi/g)**	**Pa-231 (pCi/g)**	**SOR_B (5/5/50)**	**SOR_B (15/15/50)**
Mean	2.78	1.94	1.44	0.09	1.09	0.95	1.16	0.14	0.89	0.82	0.29
Median	2.53	1.66	1.16	0.08	1.07	0.97	1.10	0.11	0.98	0.76	0.27
UCL-95	3.04	2.18	1.67	0.12	1.18	1.00	1.26	0.18	1.12	-	-
St. Dev	0.89	0.76	0.75	0.08	0.29	0.17	0.35	0.14	0.76	0.21	0.08
Range	3.93	3.19	3.19	0.33	1.25	0.82	1.59	0.80	2.55	0.95	0.35
Detects	32	32	32	0	32	32	32	7	13	-	-
No. Samples	32	32	32	32	32	32	32	32	32	32	32

SU-2 Class 3 and Biased Subsurface Soil Data Summary											
Statistic	**Ra-226**	**Th-230**	**U-238**	**U-235**	**Th-232**	**Ra-228**	**Th-228**	**Ac-227**	**Pa-231**	**SOR_G**	**SOR_N**
Mean	1.68	2.17	1.58	0.09	1.00	0.82	1.26	0.07	0.17	0.26	0.06
Median	1.39	2.13	1.41	0.05	0.95	0.82	1.11	0.04	0.14	0.25	0.03
Standard Deviation	1.12	1.27	1.04	0.19	0.63	0.32	0.80	0.19	0.47	0.13	0.09
Number of samples	57	57	57	57	57	57	57	57	57	57	57
Maximum	7.52	6.65	5.47	0.88	3.39	1.73	3.95	0.98	1.59	0.73	0.44
Range	7.42	6.65	5.40	0.88	3.39	1.66	3.95	0.98	1.59	0.66	0.44

Sample ID	Station ID	Ra-226	Th-230	U-238	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231	SOR_G	SOR_N
SLD06207	SLD06183	1.78	3.68	2.70	0.04	0.89	0.80	0.52	0.06	0.09	0.36	0.14
SLD06208	SLD06184	1.22	2.58	1.79	0.16	1.79	0.68	1.04	0.07	-0.18	0.33	0.10
SLD72610	SLD72609	2.04	2.61	0.93	0.02	1.55	1.25	1.50	0.09	0.36	0.30	0.07
SLD72611	SLD72609	2.14	1.65	1.02	0.02	1.29	1.16	1.72	0.03	0.24	0.25	0.01
SLD81674	SLD81673	0.87	1.39	1.02	-0.01	0.80	0.51	0.76	0.03	0.14	0.17	0.00
SLD81675	SLD81673	1.53	2.39	1.66	0.01	0.52	0.70	1.31	0.02	0.34	0.24	0.03
SLD81676	SLD81673	0.09	-0.07	1.46	0.88	1.62	1.73	0.86	0.08	1.45	0.15	0.05
SLD81680	SLD81679	1.35	2.73	1.35	-0.01	0.86	0.74	1.24	0.05	-0.18	0.27	0.05
SLD81707	SLD81679	1.36	3.35	1.33	0.00	0.95	0.93	1.56	-0.24	-0.25	0.31	0.09
SLD81708	SLD81679	1.33	2.92	0.07	0.09	1.03	0.93	1.57	0.00	-0.05	0.26	0.07
SLD81682	SLD81681	1.33	0.98	1.57	0.10	0.84	1.01	1.14	0.00	0.31	0.19	0.01
SLD81684	SLD81683	1.78	2.66	1.79	-0.01	0.97	0.65	0.76	-0.08	0.02	0.28	0.05
SLD81685	SLD81683	2.48	2.59	2.23	0.19	0.47	0.70	0.93	0.00	0.12	0.26	0.06
SLD81686	SLD81683	3.74	3.18	2.12	0.65	0.73	0.97	0.76	0.14	0.78	0.36	0.10
SLD81688	SLD81687	1.08	1.87	1.24	0.03	1.11	0.86	1.09	0.10	0.16	0.22	0.00
SLD81690	SLD81689	1.44	1.54	1.65	0.22	0.88	0.83	0.70	0.07	0.11	0.19	0.00
SLD82247	SLD81689	0.91	1.03	1.12	-0.11	0.44	0.60	1.11	-0.07	0.14	0.13	0.00
SLD82248	SLD81689	1.27	1.35	1.40	0.08	1.08	0.92	1.56	0.03	0.16	0.19	0.00
SLD81692	SLD81691	0.69	0.70	0.87	0.00	0.52	0.49	0.83	-0.02	0.11	0.10	0.00
SLD81693	SLD81691	0.68	1.35	0.60	0.05	0.22	0.40	0.72	0.11	0.14	0.13	0.00
SLD81694	SLD81691	0.89	0.73	0.82	-0.04	0.31	0.36	0.38	-0.06	0.35	0.10	0.00
SLD81696	SLD81695	1.66	2.71	1.57	0.13	0.93	0.93	0.93	0.00	0.02	0.27	0.05
SLD81698	SLD81697	1.39	1.81	1.34	-0.06	0.87	0.98	1.64	0.15	0.18	0.21	0.00
SLD81699	SLD81697	1.42	2.56	1.41	0.08	1.29	0.96	1.49	-0.07	0.55	0.28	0.05
SLD81700	SLD81697	1.32	1.44	1.01	0.05	0.99	0.82	1.24	0.01	0.24	0.18	0.00
SLD81702	SLD81701	1.29	2.24	1.11	-0.12	0.67	0.66	0.85	-0.07	0.23	0.22	0.02
SLD81704	SLD81703	0.70	0.83	0.66	0.03	0.42	0.30	0.45	-0.08	-0.04	0.10	0.00
SLD81710	SLD81709	0.92	1.46	1.03	0.16	1.05	0.58	1.51	0.00	0.30	0.19	0.00
SLD81712	SLD81711	1.57	2.27	1.66	0.03	1.09	1.13	2.32	0.08	0.12	0.26	0.04
SLD83586	SLD83585	1.05	2.34	1.05	0.01	1.08	0.75	1.74	-0.05	0.02	0.25	0.03
SLD84273	SLD84268	1.83	2.08	0.26	0.27	1.34	1.34	1.74	0.09	-0.62	0.23	0.04
SLD84277	SLD84268	1.75	2.28	1.77	0.04	1.30	1.05	1.14	-0.09	0.20	0.27	0.04
SLD84966	SLD84268	1.87	2.29	1.91	0.09	1.51	1.22	1.73	0.13	-0.09	0.29	0.06
SLD84281	SLD84269	1.62	1.10	1.05	-0.02	0.43	0.67	0.38	-0.08	0.14	0.17	0.00

Table 5. SU-2 Class 3 and Biased Subsurface Soil Data Summary (Con't)

Sample ID	Station ID	Ra-226	Th-230	U-238	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231	SOR_G	SOR_N
SLD84282	SLD84269	2.96	1.98	2.60	0.60	0.62	1.10	0.64	0.10	-1.65	0.32	0.05
SLD84283	SLD84269	1.88	2.13	2.12	-0.17	1.25	1.21	0.87	-0.21	0.48	0.27	0.04
SLD84274	SLD84270	1.01	1.35	0.63	-0.12	0.00	0.18	0.00	-0.03	0.04	0.11	0.00
SLD84967	SLD84270	1.97	1.27	1.44	0.02	0.20	0.07	0.32	0.13	0.96	0.17	0.00
SLD84279	SLD84271	1.35	1.03	2.01	0.37	0.77	0.72	0.84	0.38	0.64	0.18	0.01
SLD84276	SLD84272	1.38	1.34	2.05	-0.25	1.07	1.05	0.79	0.33	0.26	0.20	0.02
SLD84280	SLD84272	1.23	1.67	1.02	0.19	0.65	0.65	0.60	0.11	-1.27	0.18	0.00
SLD84971	SLD84272	1.34	1.76	1.46	0.01	1.32	0.97	1.08	0.29	0.24	0.23	0.02
SLD84275	SLD84275	1.28	0.83	1.01	0.10	0.48	0.58	0.74	0.02	-0.01	0.14	0.00
SLD85143	SLD85142	1.52	1.21	1.46	-0.04	0.12	0.41	0.38	0.06	0.11	0.16	0.00
SLD85144	SLD85142	1.53	2.66	1.21	0.06	1.53	0.92	2.64	0.03	-0.13	0.30	0.08
SLD85145	SLD85142	1.38	2.27	1.39	0.01	1.01	0.74	1.36	0.00	-0.04	0.25	0.02
SLD85147	SLD85146	3.39	2.66	2.65	-0.16	2.73	1.20	3.84	0.22	0.10	0.46	0.18
SLD85148	SLD85146	7.52	6.25	5.25	0.10	1.87	0.86	2.23	0.25	0.53	0.73	0.44
SLD85149	SLD85146	1.67	2.21	0.93	0.11	2.52	1.07	2.70	0.04	0.17	0.33	0.11
SLD87647	SLD87647	5.02	5.11	5.47	0.40	0.63	1.04	1.24	-0.08	0.32	0.52	0.30
SLD87648	SLD87647	2.62	4.01	1.74	0.12	1.06	0.82	1.50	0.29	1.59	0.37	0.14
SLD87649	SLD87649	2.08	2.90	1.49	0.05	1.51	0.78	2.37	-0.31	0.47	0.32	0.09
HTZ68163	HTZ66325	0.78	0.67	0.13	0.00	0.12	0.31	0.61	0.04	0.12	0.08	0.00
HTZ66327	HTZ66326	1.92	2.50	4.55	0.32	1.18	0.98	1.15	0.22	0.17	0.34	0.11
HTZ68154	HTZ68154	1.71	4.18	1.83	0.10	3.39	1.55	3.95	0.98	0.46	0.54	0.31
HTZ68155	HTZ68154	0.50	0.61	0.29	0.09	0.09	0.37	0.36	0.23	0.12	0.07	0.00
HTZ68162	HTZ68161	1.39	6.65	2.83	0.15	0.94	0.75	2.51	0.52	0.12	0.56	0.34

Notes:

SOR_B = sum of ratio for the background soils.

Results are expressed in pCi/g; SOR values are unitless.

Protactinium 231 (Pa-231), Actinium 227 (Ac-227)

5.0 REVIEW FSS DESIGN

5.1 FSS Design

The FSSP specifies the design for the FSS and, in order to meet the minimum statistical requirements (i.e., WRS Test), estimates eleven systematic samples per SU. The FSSP systematic sample estimation uses historical SU data and standard deviations (σ) from SLDS. Once property-specific FSS data were available, the calculation of the number of samples needed to support the WRS test was repeated for SU-1 and SU-2 to confirm that sufficient samples had been collected. When actual SU data is available, the actual SU standard deviation and mean SOR_N can be determined. Therefore, it is appropriate to set the lower bound of the gray region (LBGR) at the mean SOR_N concentration when reviewing the SU retrospectively. Twenty-one systematic surface soil samples were collected in SU-1 and 24 were collected in SU-2.

When the difference between the maximum gross systematic SU measurement and the minimum reference area measurement within a SU are greater than the $DCGL_W$, [i.e., sum of ratios gross (SOR_G)>1] the WRS statistical test is used to further demonstrate that the SU as a whole meets the concentration-based RG. In the case of SU-1 and SU-2 the maximum gross measurement minus the minimum reference area measurement results in an SOR_G <1, per guidance found in MARSSIM (i.e., "if the difference between the largest SU measurement and the smallest reference area measurement is less than or equal to the $DCGL_w$ the WRS will always show the SU meets the release criterion"[DOD 2000]); therefore, a WRS test is not included with this report.

5.2 SU-1 FSS Design

The relative shift (Δ/σ) was calculated for SU-1 using values for the SOR_N, LBGR, and σ. The SOR_N was set to 1.0, the LBGR was set at 0.02 mean SOR_N. The value for Δ was therefore, SOR_N - LBGR = (1.0) - (0.02) = 0.98. The specific values of σ for SU-1 surface soils gross values are: Ra-226 = 0.70 pCi/g; U-238 = 1.10 pCi/g; Th-230 = 0.63 pCi/g and Th-232 = 0.33 pCi/g. Using these values, the weighted σ was calculated as shown below.

$$\sigma = \sqrt{\left(\frac{\sigma_{Ra-226}}{DCGL_{Ra-226}}\right)^2 + \left(\frac{\sigma_{U-238}}{DCGL_{U-238}}\right)^2 + \left(\frac{\sigma_{Th-230}}{DCGL_{Th-230}}\right)^2 + \left(\frac{\sigma_{Th-232}}{DCGL_{Th-232}}\right)^2} = \sqrt{\left(\frac{0.70}{5}\right)^2 + \left(\frac{1.10}{50}\right)^2 + \left(\frac{0.63}{5}\right)^2 + \left(\frac{0.33}{5}\right)^2} = 0.20$$

Using this value and Δ = 0.98, the Δ/σ for SU-1 was greater than four. When the actual SU data is evaluated retrospectively and the Δ/σ is greater than 4 there will be no further change in the required number of samples. These values were calculated using actual SU-1 sample data results. From Table 5.3 in MARSSIM and given 0.05 for the Type I error and 0.20 for the Type II error, the minimum number of surface samples required for SU-1 was determined to be 5. Twenty-one Class 2 systematic surface samples were actually collected from SU-1. This demonstrates that a more than adequate number of samples were collected to satisfy the statistical testing.

5.3 SU-2 FSS Design

The Δ/σ was calculated for SU-2 using values for the SOR_N, LBGR, and σ. The SOR_N was set to 1.0, the LBGR was set at 0.06 mean SOR_N. The value for Δ was therefore, SOR_N - LBGR = (1.0) - (0.06) = 0.94. The specific values of σ for SU-2 surface soils gross values are: Ra-226 = 0.77 pCi/g; U-238 = 0.91 pCi/g; Th-230 = 0.72 pCi/g and Th-232 = 0.39 pCi/g. Using these values, the weighted σ was calculated as shown below.

$$\sigma = \sqrt{\left(\frac{\sigma_{Ra-226}}{DCGL_{Ra-226}}\right)^2 + \left(\frac{\sigma_{U-238}}{DCGL_{U-238}}\right)^2 + \left(\frac{\sigma_{Th-230}}{DCGL_{Th-230}}\right)^2 + \left(\frac{\sigma_{Th-232}}{DCGL_{Th-232}}\right)^2} = \sqrt{\left(\frac{0.77}{5}\right)^2 + \left(\frac{0.91}{50}\right)^2 + \left(\frac{0.72}{5}\right)^2 + \left(\frac{0.39}{5}\right)^2} = 0.23$$

Using this value and $\Delta = 0.94$, the Δ/σ for the SU-2 was greater than four. When the actual SU data is evaluated retrospectively and the Δ/σ is greater than 4 there will be no further change in the required number of samples. These values were calculated using actual SU-2 sample data results. From Table 5.3 in MARSSIM and given 0.05 for the Type I error and 0.20 for the Type II error, the minimum number of surface samples required for SU-2 was determined to be 5. Twenty-four Class 3 randomly distributed samples were actually collected from SU-2. This demonstrates that a more than adequate number of samples were collected to satisfy the statistical testing.

6.0 DATA EVALUATION

A data review provides a preliminary attempt to identify patterns and anomalies in the data and may provide an early indication of whether a SU will pass or fail statistical tests (i.e., whether additional material should be removed). This review includes the following four components.

1. A review of data quality indicators (DQIs).
2. A comparison of SU data to the concentration-based RGs.
3. A comparison of SU data to reference area data and a review of relevant parameters (e.g., mean, median, standard deviation, etc.); and,
4. A residual risk and dose assessment for the property as a whole.

The DQA utilizes actual data collected from SU-1, SU-2 and the reference background areas to evaluate the FSS results.

6.1 DQIs

FSS sample data was reviewed for precision, accuracy, representativeness, completeness, and comparability. DQIs are summarized in the FSSP and are presented in detail in the Quality Assurance (QA) section of the Sampling and Analysis Guide (SAG) (USACE 2000).

Precision and accuracy are determined by the analysis of field duplicate samples and split samples. Precision is measured by comparing the analytical results of the field duplicates, which are samples collected at the same location as the field sample they duplicate and analyzed in the same laboratory. Accuracy is measured by comparing the results of split samples, which are aliquots of field samples analyzed by a separate laboratory. SU-1 and SU-2 split samples were analyzed by Severn-Trent Laboratories.

The DQOs established in the FSSP require that 5% of the total number of samples be duplicated and split with another laboratory. A total of eight splits and nine duplicates were obtained for 154 Class 2 and Class 3 samples (i.e., surface and subsurface). This achieved the DQO of 5% for duplicate and split samples.

Field duplicate and split sample results were evaluated to assess the general precision and accuracy obtained during the course of these investigations. Isotopic values for U-238, Th-230, Th-232, Ra-226, and Ra-228 were compared for the nine field duplicate pairs and eight QA split sample pairs. Evaluation criteria were set at a relative percent difference (RPD) of ± 30% or less at 50% of the RG or less than 1.96 for the normalized absolute difference (NAD). Based on these evaluation criteria, 100% of the field duplicate comparisons indicated acceptable precision, and 100% of the QA split sample comparisons indicated acceptable accuracy. Given the inherent heterogeneity of soils and the low levels of activity being measured (most values were determined at levels below 5 pCi/g), the precision and accuracy for this work are considered acceptable and the data are useable for their intended purpose.

Representativeness, comparability, and completeness are subjective decisions based on the sampling strategy and the ability of the data to meet requirements. Data were collected according to the FSSP using MARSSIM guidance for Class 2 and Class 3 sampling techniques to ensure representativeness of the data to actual property conditions. The data were collected and analyzed according to the methods presented in the SAG (USACE 2000). The data were verified and validated according to the Quality Assurance Project Plan (QAPP). The detailed results of the quality control (QC) analysis for SU-1 and SU-2 data are provided in Attachment B, Quality Control Summary Report (QCSR).

6.2 Comparison to Concentration-Based RGs

The RG for SLDS, is stated in Section 1.0. Each SU was evaluated to determine that the average SOR_N over the entire SU did not exceed 1.0 (Tables 2, 3, 4 and 5) and that the areal average Ra-226 concentration over any 100 m^2 area did not exceed 5 pCi/g in any 15 cm (0.5 ft) surface soil layer or more than 15 pCi/g in any 15 cm (0.5ft) thick subsurface soil layer (Attachment D). Results from the Class 2 and Class 3 surface samples must also satisfy the WRS test, if required (Section 5.1).

The mean systematic sample SOR_N for the SUs were well below 1.0. (Systematic SOR_N values ranged between 0.00-0.37 for SU-1 and 0.00 – 0.39 for SU-2). The data is summarized in Table 2 and Table 4, respectively.

Mallinckrodt West (SU-1) contains five biased sample results having an SOR_N greater than 1.0. These areas comply with the areal average stated in the ARAR-based RG. An evaluation was performed that consisted of obtaining an area weighted average SOR_N of all the adjacent samples that fell within 100 m^2 (Attachment D). The areas assigned to these samples used for the weighted average are based on gamma walkover data and surrounding samples that bound the elevated samples. The area that a biased sample represents in Attachment D may have been increased in order to determine a conservative 100 m^2 weighted average SOR value. These areas comply with the areal average stated in the ARAR-based RG.

6.3 Statistical Test

Because the radionuclide COCs are present in background for both SUs, the WRS test is the appropriate statistical test for SUs consisting of soil. When the difference between the largest SU systematic measurement and the smallest reference area measurement is less than the $DCGL_W$, the WRS test will always show that the SU meets the RG. Such is the case for SU-1 and SU-2. The WRS test is not necessary to demonstrate compliance with the RGs.

6.4 Comparison to the Reference Area and Evaluation of Parameters

Sample results for FSS surface soil sample data, biased surface soil sample data, subsurface soil sample data and subsurface biased soil sample data are presented in Tables 2, 3, 4 and 5, respectively. Reference area data are also summarized in Tables 2, 3, 4 and 5. A review of the data shows that the primary COCs are U-238, Th-230, and Ra-226. Results for other radionuclides are generally within range of background and contribute negligibly to the SOR_N calculation.

The reported radionuclide concentrations from the laboratory were used in this report even if below the minimum detectable concentration (MDC). This data was used to complete the MARSSIM evaluation and accesses the risk and dose for the SUs. MARSSIM recommends that analytical methods should be capable of measuring levels at 10-50% of the established concentration based RG. MDCs for U-238, Th-230, Th-232, and Ra-226 achieved levels below 50% of the RG.

The comparison of FSS data to reference area data and RGs confirm that data are sufficient to assess the pending release of accessible areas.

7.0 RESIDUAL RISK AND DOSE ASSESSMENT

A conservative property-specific residual risk and dose assessment was performed for West of Broadway VPs and Mallinckrodt West properties. The risk and dose assessment was performed in accordance with the SLDS ROD to confirm that the West of Broadway VPs and Mallinckrodt West properties had been protectively remediated and to verify that the selected remedy had met the response action objectives regarding risk and dose criteria so that the West of Broadway VPs and Mallinckrodt West properties could be released for use without any radiological restriction. The ROD for SLDS established the Comprehensive, Environmental Response, Compensation, Liability Act (CERCLA) target risk range as the risk criteria, and the 10 CFR 20 Subpart E dose limit of 25 mrem/yr as the dose criteria for SLDS (USACE 1998b). The USEPA defines the CERCLA target risk range as 10^{-6} to 10^{-4} where "the upper boundary of the risk range is not a discrete line at 1E-04. A specific risk estimate around 10^{-4} may be considered acceptable if justified based on site-specific conditions" (USEPA 1997a).

RESRAD (Residual Radioactivity) Version 6.3 was used for the risk and dose assessment for West of Broadway VPs and Mallinckrodt West Properties to calculate risk and dose to the potential receptors. RESRAD is a computer code developed at Argonne National Laboratory for the DOE to determine site-specific residual radiation guidelines and dose to a future hypothetical on-site receptor at sites that are contaminated with residual radioactive materials. The use of RESRAD codes for modeling risk and dose has become an acceptable standard industry practice. For example:

- The USEPA used RESRAD in its "Reassessment of Radium and Thorium Soil Concentrations and Annual Dose Rates" that demonstrated the protectiveness of Uranium Mill Tailings Radiation Control Act (UMTRCA) soil criteria and in its rulemaking for cleanup of sites contaminated with radioactivity.
- Seven U.S. Cabinet-level agencies including EPA, DOE, NRC, and DOD, functioning as the Interagency Steering Committee on Radiation Standards formally accepted RESRAD-BIOTA.
- The USEPA was also a signatory to both SLDS and North St. Louis County Sites ROD.

Residual risk and dose assessments in the SLDS ROD were performed using RESRAD Version 5.62. RESRAD 5.62 incorporates the HEAST 1995 morbidity slope factors, whereas RESRAD 6.3 incorporates Federal Guidance Report (FGR) 13 morbidity slope factors. The newer FGR 13 slope factors are pathway specific and are more conservative for the SLDS COCs.

Risk and dose scenarios for the SLDS ROD are based on the industrial/utility worker and industrial/construction worker exposure scenarios defined in the SLDS Feasibility Study (FS) (USACE 1998b). The assessments for this property were performed for each of these scenarios and an additional onsite residential scenario was considered at the request of regulators.

The input parameters selected for the utility and industrial worker scenarios are those defined in the SLDS FS (USACE 1998b). The input parameters selected for the onsite residential receptor scenario are those defined for the onsite residential receptor in the Post-Remedial Action Report for the Accessible Soils Within the St. Louis Downtown Site Plant 2 Property (USACE 2002b). Table 6 presents the non-default RESRAD input parameters for the three receptors. Each receptor scenario is summarized as follows:

1. Industrial Worker: The industrial worker is modeled as a typical site worker who spends most of their time indoors. The worker is at the property for 250 days per year for 25 years. During a standard year, the industrial worker is assumed to spend 1600 hours indoors and 400 hours outdoors plus 125 hours (0.5 hours per day) indoors to account for the possibility of eating lunch on the property, early daily arrival or late daily departure.

2. Utility Worker: The utility worker may participate in utility work or other intrusive outdoor activities at the property. It is assumed that the utility worker is exposed in a single event that takes place over an 80-hour period.

3. Onsite Residential Receptor: The onsite residential receptor is modeled as a potential future receptor in case the current land use areas being assessed changes to residential. The residential receptor is assumed to live on site for 350 days per year for 30 years (USEPA 2000b). The resident is assumed to spend 16.4 hours indoors and 2.0 hours outdoors each day (USEPS 1997b). Among outdoor activities, the resident is assumed to spend 0.2 hours each day for gardening.

Table 6. RESRAD Non-default Input Parameters

Category	Parameter	Values		
Physical Parameters	Area of Contaminated Zone (m^2)	SU-1	9,792	
		SU-2	49,331	
		West of Broadway VPs and Mallinckrodt West properties	59,123	
	Thickness of the Contaminated Zone (m)	2		
Cover Parameters	Cover Depth (m)	0		
	Density of the Cover Material (g/cm^3)	Not Applicable		
	Cover Erosion Rate (m/yr)	Not Applicable		
Hydrological Data for Contaminated Zone	Density of Contaminated Zone (g/cm^3)	1.28 (Clay Loam)		
	Contaminated zone Total Porosity (unitless)	0.42 (Clay Soil)		
	Contaminated zone Field Capacity (unitless)	0.36		
	Contaminated zone Hydraulic Conductivity (m/yr)	3.048		
	Contaminated zone b parameter (unitless)	10.4		
	Wind Speed (m/s)	4.17		
	Precipitation (m/y)	0.92		
	Irrigation (m/y)	0		
	Run off Coefficient (unitless)	0.8 (Built-Up Area)		
	Contaminated zone Erosion Rate m/yr	0.00006		
Exposure Parameters		**Onsite Resident**	**Utility Worker**	**Industrial Worker**
	Inhalation Rate (m^3/yr)	8400	10,550	10,550
	Mass Loading for Inhalation (g/m^3)	5.9E-06	0.0002	0.0002
	Exposure Duration (yr)	30	1	25
	Indoor Dust Filtration Factor (unitless)	0.5	0.5	0.5
	External Gamma Shielding Factor	0.7	0.7	0.7
	Indoor Time Fraction (unitless)	0.655	0	0.1969
	Outdoor Time Fraction (unitless)	0.0799	0.0091	0.04566
	Fruit, Vegetable, and Grain Consumption (kg/yr)	42.7	Not Applicable	Not Applicable
	Leafy Vegetable Consumption (kg/yr)	4.66	Not Applicable	Not Applicable
	Soil Ingestion (g/yr)	43.8	175.2	49.64

Each receptor in the three scenarios are exposed to the radiologically contaminated soil through the following three exposure pathways – external gamma, inhalation, and soil ingestion. The onsite resident scenario also includes plant ingestion pathways. Since groundwater is not a potential source of drinking water for the SLDS, the drinking water pathway is not considered as a potential pathway for the property.

Risk and dose for West of Broadway VPs and Mallinckrodt West properties were performed by developing a source term for the radiological contamination. The source terms for both are based upon exposure point concentrations (EPCs). The EPC is a representative concentration to which a receptor will be exposed over the exposure period.

For radiological contamination, the EPCs were determined for each survey unit (SU) and the West of Broadway VPs and Mallinckrodt West properties. The EPCs for the West of Broadway VPs and Mallinckrodt West properties were applied to each receptor scenario using RESRAD. The following paragraphs summarize the process for calculating EPCs for each COC at each SU.

West of Broadway VPs and Mallinckrodt West properties include one class 2 SU, and one class 3 SU. All SUs include systematic, subsurface, and biased samples. For those SUs, a representative area equal to the SU area divided by the number of systematic sampling locations was established for each systematic sampling location. Systematic sample locations are those locations where samples were taken to perform the MARSSIM statistical tests. Then an area-weighted average concentration for each radionuclide COC was determined for each representative area based on the area and concentration results of both systematic and biased samples within that representative area by using the following equation.

$$C_{RA} = \frac{\sum\left(\frac{C_S \, x\left(R_A - \sum A_B\right)}{N_S}\right) + \sum\left(C_B \, x \, A_B\right)}{R_A}$$

Where;

C_{RA} = Concentration of the representative area
C_S = Concentration of the systematic sample
R_A = Representative area value
C_B = Concentration of the biased sample
A_B = Area of the biased sample
N_S = Number of samples per systematic sample location (e.g., samples at different depths)

The area-weighted average COC concentrations for each representative area were used to determine the UCL_{95} (95% Upper Confidence Limit of the mean) value for each SU. Determination of the UCL_{95} for each radionuclide depends upon the distribution type (i.e., normal, lognormal, etc.) of the sampling results. The EPA designed software ProUCL (Version 3.0) was used to determine the distribution type of sampling results. The software determines the UCL_{95} based on the distribution type.

The EPCs for each SU were determined by subtracting the average background concentration from the smaller of the UCL_{95} or the maximum detected concentration. The EPCs for the West of Broadway VPs and Mallinckrodt West properties were calculated by using area-weighted EPCs from each SU. The EPCs for each SU and the West of Broadway VPs and Mallinckrodt West properties are presented in Table 7.

Table 7. EPCs for Each SU, West of Broadway VPs and Mallinckrodt West properties

Sites	Statistic	Radionuclide Concentrations (pCi/g)								
		Ra-226	Th-230	U-238	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231
Class 2 SU-1 (Area 9,792m^2)	Background	2.78	1.94	1.44	0.09	1.09	0.95	1.16	0.14	0.89
	Maximum	3.10	3.34	2.92	0.25	1.23	1.09	1.56	0.20	0.46
	Distribution	N	G	N	N	G	N	N	N	N
	UCL (Distribution)	2.09	2.13	2.01	0.12	0.85	0.79	1.03	0.04	0.15
	EPC	**0.00**	**0.19**	**0.57**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Class 3 SU-2 (Area 49,331m^2)	Background	2.78	1.94	1.44	0.09	1.09	0.95	1.16	0.14	0.89
	Maximum	3.19	5.94	3.02	0.26	1.77	1.17	2.03	0.21	0.33
	Distribution	N	G	G	N	N	N	N	N	NP
	UCL (Distribution)	1.80	1.80	1.75	0.10	1.01	0.83	1.22	0.06	0.14
	EPC	**0.00**	**0.00**	**0.31**	**0.01**	**0.00**	**0.00**	**0.06**	**0.00**	**0.00**
West of Broadway VPs Mallinckrodt West properties (59,123m^2)	**Area Weighted EPC**	**0.00**	**0.03**	**0.35**	**0.01**	**0.00**	**0.00**	**0.05**	**0.00**	**0.00**

N= Normal, G– Gamma, NP=Non Parametric

Table 8 summarizes the highest radiological risk and dose in a 1,000-year period to each of the three receptors from exposure to the residual radionuclides present at the West of Broadway VPs and Mallinckrodt West properties

Table 8. Highest Risk and Dose for Property to Different Receptors

Industrial Worker		Utility Worker		Onsite Resident	
Dose (mrem/yr)	Risk	Dose (mrem/yr)	Risk	Dose (mrem/yr)	Risk
0.4	7 E-06	0.02	1 E-08	1.6	3 E-05

The SLDS ROD requires dose and risk analyses for the utility and industrial worker scenarios. In addition, a dose and risk analysis were performed for the onsite residential scenario. Results for all three scenarios were within the CERCLA risk range. The RESRAD results indicate that the onsite residential receptor has the highest risk and receives the highest dose among the three receptors. The highest residential risk and dose were 3E-05 and 1.6 mrem/yr, respectively. The doses for all three receptor scenarios were within the acceptable CERCLA risk range and below 25 mrem/yr. The actual property risk for all scenarios would be lower than the calculated risk since:

- Cover was not taken into consideration, and
- Assumptions used to calculate residual risk are much more conservative than conditions required for removal action (USACE 1998a).

Therefore, based on the results of risk and dose assessments, it can be concluded that residual risk and dose for the properties addressed by this report are protective for all potential receptor scenarios and the property can be released for use without any land use restrictions.

RESRAD output files for all modeled scenarios and the West of Broadway VPs and Mallinckrodt West properties EPC calculations are on file as part of the FUSRAP Record for the SLDS.

8.0 INACCESSIBLE/EXCLUDED AREA EVALUATION

The approach used to delineate the inaccessible soils was derived directly from the ROD definition of accessible soils. The ROD defines accessible soils as soils that are not beneath buildings or other permanent structures (e.g., active rail lines, roadways, the levee). The ROD states that "inaccessible soils containing MED/AEC contamination and associated buildings and structures are excluded from the scope of the ROD because they do not present a significant threat in their current configuration and because activities critical to the continued operation of the Mallinckrodt facility prevent excavation beneath the encumbrances." (USACE 1998a) Inaccessible soils at the West of Broadway VPs and Mallinckrodt West Property are not within the scope of the SLDS ROD and will be addressed at a later time. In addition, soils beneath buildings constructed prior to 1940 are considered not impacted by radiological contamination unless site specific evidence indicates otherwise.

Areas determined to be not impacted or inaccessible are shown in Figure 2. Buildings are defined as the footprint of the structure, supporting soil beneath the footprint, and soil adjacent to the building necessary for structural stability of the building. Roadways and rail lines are defined as the applicable right-of-way and supporting soil.

An area approximately 50 m^2 in size located in the northeast corner of Plant 9 is excluded from this report and will be addressed by a post-remedial action report subsequent to its remediation.

9.0 CONCLUSIONS

Comparison to ROD Criteria

The Remedial Action Objectives (RAOs) for SU-1 and SU-2 apply to areas affected by the MED/AEC uranium manufacturing and processing activities. This section lists (i.e., bullet/italicized items) each ROD remedial action objectives (i.e., RGs) and describes how the USACE is demonstrating compliance with the RG.

- *Excavation of accessible soils according to the ARAR-based composite cleanup criteria (i.e., RG) of 5/15 pCi/g above background for Ra-226, Ra-228, Th-232, and Th-230, and 50 pCi/g above background for U-238 in the uppermost 1.8 m (6 ft) (USACE 1998a).*

  The 5/5/50 RG was used for comparison against the data collected from surface soils in the first 15 cm (0.5 ft) below the ground surface or below ground cover material (e.g., asphalt) regardless of thickness, as applicable. The 15/15/50 subsurface RG was used for comparison against the data collected in accessible soils below 15 cm (0.5 ft). In SU-1 and SU-2, soil samples were collected in the initial soil layer (below cover) and generally at 45-60 cm (1.5-2.0 ft) intervals bgs to a depth of 1.8 m (6ft). All SU-1 and SU-2 samples have SOR_N values of less than 1.0 when averaged over the SU. Therefore, the SU data demonstrates compliance with this ROD RG. Details on the SOR_N results can be found in Tables 2, 3, 4 and 5.

  In addition, the 40 CFR 192 ARAR for surface/subsurface soils (5/15 pCi/g Ra-226 averaged over 100 m^2) was used for comparison against the data collected in accessible soils in the SUs. The average Ra-226 concentration was less than the RG. Details on the 100 m^2 areal average results can be found in Section 6.2 of this report.

- *On the portion of the Mallinckrodt property addresses in the OU, site-specific target removal levels of 50 pCi/g above background for Ra-226, 100 pCi/g above background for Th-230, and 150 pCi/g above background for U-238 (50/100/150 RGs) will be used as the deep-soil cleanup guidelines (RG) below 1.8 m (6 ft) as described in Section 7.3.6 of the ROD (USACE 1998a).*

  Although, deep soil RGs do not apply to VPs, they do apply to Mallinckrodt properties. No samples at a depth greater than 1.8 m (6 ft) exceeded an $SOR_N > 1$ for mid criteria so the application of deep criteria is not relevant to this Mallinckrodt property *for arsenic and cadmium:*

  1) *Within the upper 1.2 or 1.8 m (4 or 6 ft) of grade, soil concentrations of arsenic greater than 60 mg/kg and/or cadmium concentrations greater than 17 mg/kg will be removed, or*

  2) *Below 1.2 or 1.8 m (4 or 6 ft) of grade, soil concentrations of arsenic greater that 2500 mg/kg and/or cadmium are greater than 400 mg/kg will be removed (USACE 1998a).*

  Per the ROD, arsenic and cadmium requirements are not applicable to the areas addressed by this report

- *Remediation goals for radiological contaminants are applied to soil concentrations above background consistent with the ARAR (40 CFR 192), from which they derive. However, addition of background concentrations to these goals would not alter any judgments regarding protectiveness. Remediation goals for non-radiological RGs*

are applied to soil concentrations including background consistent with the National Oil and Hazardous Substances Contingency Plan *(NCP) (USACE 1998a).*

This statement in the ROD is true for SU-1 and SU-2. The SOR_G for the SU (the raw data including background) is also less than 1.0 when averaged across the SU. SOR_G calculations for the SU can be found in Section 4.0. Per the ROD, chemical RGs are not applicable to areas included in SU-1 and SU-2.

- *Compliance with soil contamination criteria (RGs) will be verified by methods that are compatible with MARSSIM for soils being cleaned up in the OU effective with MARSSIM publication. (A representative number of samples obtained in the bottom of excavations will also be subjected to chemical analysis and comparison to chemical RGs.) (USACE 1998a).*

  The FSSP was designed in accordance with MARSSIM methodology and applied to the areas (i.e., SU-1 and SU-2). Class 2 SUs are limited in size per MARSSIM guidance. Class 3 SU sizes are unlimited per MARSSIM guidance. Details on SU areas can be found in Section 3.0 of this report.

  SU-1 and SU-2 had no individual systematic or randomly distributed samples in which the largest SU measurement minus the smallest reference area measurement resulted in a value greater than the $DCGL_W$, therefore the SUs did not require a WRS statistical test to demonstrate compliance with RGs. Although the WRS test was not required, FSS data were evaluated to demonstrate that sufficient samples were collected for each SU. Details on the calculation for the number of samples to satisfy statistical testing can be found in Section 5.0 of this report.

  Per the ROD, chemical analysis is not required for areas addressed by this report

- *A post-remedial action risk assessment will be performed to describe the level of risk remaining from MED/AEC contaminants following completion of remedial activities (USACE 1998a).*

  A post-remedial action risk and dose assessment was performed for the modeled scenarios stated in the ROD. In addition, regulators requested that the USACE develop an on-site residential scenario to document protectiveness if land use changed from industrial to residential. The residual risk and dose calculated for SU-1/SU-2 is less than or equal to 3 E-05 and 1.6 mrem/yr , respectively for all modeled scenarios (i.e., Industrial Worker, Utility Worker, and On-site Resident) without regard to any cover material. The actual property risk for all scenarios would be lower than the calculated risk, since no cover (e.g., asphalt) was taken into consideration during the risk and dose assessment. The risk and dose from actual residual conditions on SU-1 and SU-2 are considered acceptable to release the accessible areas without restrictions. Details of the risk and dose assessment can be found in Section 7.0 of this report.

- *Final determinations as to whether institutional controls and use restrictions are necessary will be based on calculations of post remedial action risk derived from actual residual conditions. Five-year reviews will be conducted per the NCP for residual conditions that are unsuitable for release without restrictions (USACE 1998a).*

  The risk and dose from actual residual conditions (without regard to cover materials) are acceptable to release SU-1 and SU-2 accessible areas without restrictions. There

are no accessible areas on either SU where it is necessary to apply restrictions or institutional controls. Details of the risk and dose assessment can be found in Section 7.0 of this report.

- *Institutional controls may include land use restrictions for those areas having residual concentrations of contaminants unsuitable for unrestricted use. This determination will be made based on risk analysis of the actual post-remedial action conditions. Until a decision is developed to address the ultimate disposition of inaccessible soils, steps will be taken to control uses inconsistent with current uses and to learn of anticipated changes in conditions that might make these soils accessible or increase the potential for exposure. Periodic reviews with affected property owners will be conducted throughout the duration of active site remediation. For residual conditions requiring use restrictions after the period of active remediation, coordination with property owners and local land use planning authorities will be necessary to implement deed restrictions or other mechanisms to maintain industrial/commercial land use (USACE 1998a).*

  The risk and dose from actual residual conditions (without regard to cover materials) are acceptable to release SU-1 and SU-2 accessible areas without restrictions. Details of the risk and dose assessment can be found in Section 7.0 of this report. There are no accessible areas at SU-1 or SU-2 where it is necessary to apply restrictions or institutional controls. There were no identified areas that were excluded from remediation because of an inaccessibility determination

- *A long-term ground-water monitoring strategy will be implemented to confirm expectations that significant impacts to the Mississippi Alluvial Aquifer (B unit) will not occur. Although groundwater use in this area is not anticipated, agreements will be proposed to state and local water authorities to prevent well drilling, which may be impacted by the surficially contaminated A unit (USACE 1998a).*

  The areas covered by this report have no ground-water monitoring wells, however a long-term ground-water monitoring strategy for SLDS has been implemented to confirm expectations that significant impacts to the Mississippi Alluvial Aquifer (B unit) will not occur. Only a thin wedge of the B unit underlies the easternmost portion of this site. An Environmental Monitoring Guide for the St. Louis Sites (USACE 1999) has been written and is currently being implemented by the USACE through Environmental Monitoring Implementation Plans for each fiscal year.

- *Perimeter wells in the Mississippi Alluvial Aquifer will be monitored to determine if further action will be required with respect to ground water (USACE 1998a).*

  The areas covered by this report have no ground-water monitoring wells, however SLDS perimeter wells in the Mississippi Alluvial Aquifer are being monitored in accordance with the Environmental Monitoring Guide for the St. Louis Sites. The requirements in the guide are currently being implemented by the USACE through Environmental Monitoring Implementation Plans for each fiscal year. These requirements include perimeter well ground-water monitoring.

- *Pa-231 and Ac-227 will be included in the analyses for the post-remedial action residual site risk (USACE 1998a).*

  Pa-231 and Ac-227 were included in the residual risk and dose assessments.

- *Contaminated sediments in sewers and drains considered to be accessible will be remediated along with the soils (USACE 1998a).*

Potentially impacted sewers are limited to those that provided service to MED/AEC areas of Mallinckrodt property. As such, no impacted sewers have been identified on vicinity properties west of Mallinckrodt property.

10.0 SUMMARY

The residual radioactivity in SU-1 and SU-2 meets all requirements specified in the ROD. This conclusion is the result of comparison of ROD requirements and the residual site conditions. The concentration based RGs for Th-230, Ra-226, Th-232, Ra-228, and U-238 are satisfied, noting that no SOR_N value exceeds the RG of 1.0 when averaged over the SU (the average SOR_N excluding mean site background in SU-1 and SU-2 was 0.02 and 0.06 respectively) and no Ra-226 concentration averaged over 100 m^2 exceeds 5 or 15 pCi/g. The dose-based ARAR from 10 CFR 20 Subpart E, "Radiological Criteria for License Termination" has been satisfied noting that the residual risk and dose calculated for SU-1 and SU-2 is less than or equal to 3E-05 and 1.6 mrem/yr, respectively for all modeled scenarios (i.e., Industrial Worker, Utility Worker, and On-Site Resident) without regard to existence to cover material. SU-1 and SU-2 would satisfy the statistical requirements for a WRS test if required (See Section 5.1). Soil concentrations comply with 40 CFR 192 unrestricted release criteria. SU-1 and SU-2 meet all ROD requirements and can be released without radiological restrictions.

11.0 REFERENCES

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ATTACHMENT A

FSS SOIL SAMPLE DATA

Table A-1. Final Status Survey Soil Sample Data

Survey Unit	Sample Name	Station Name	Ac-227			Pa-231			Ra-226			Ra-228			Th-228			Th-230			Th-232			U-235			U-238		
			VQ[1]	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA
SU-1	HTR84767	HTR84767	U	0.14	0.19	UJ	0.35	0.53	=	1.46	0.05	=	0.35	0.06	J	0.70	0.36	=	3.36	0.27	J	0.67	0.27	UJ	0.05	0.24	=	1.35	0.35
SU-1	HTR84774	HTR84767	UJ	-0.09	0.18	UJ	0.21	0.52	=	1.36	0.05	=	0.38	0.07	J	0.77	0.48	=	2.06	0.16	U	0.29	0.31	UJ	0.10	0.26	=	1.95	0.38
SU-1	HTR84768	HTR84768	=	0.24	0.24	UJ	0.33	0.58	=	1.98	0.05	=	0.49	0.06	J	0.90	0.27	=	14.30	0.27	=	1.18	0.15	U	0.32	0.28	=	2.63	0.41
SU-1	HTR84775	HTR84768	=	0.49	0.29	UJ	0.68	0.78	=	3.33	0.06	=	0.56	0.08	J	0.64	0.28	=	19.40	0.28	J	0.70	0.24	U	0.27	0.34	=	4.74	0.53
SU-1	HTR84776	HTR84768	=	0.47	0.27	UJ	0.47	0.79	=	3.04	0.07	=	0.61	0.09	J	0.63	0.23	=	10.30	0.12	J	0.32	0.12	UJ	0.18	0.38	=	4.40	0.57
SU-1	HTR84769	HTR84769	UJ	0.06	0.17	UJ	0.26	0.47	=	1.33	0.04	=	0.38	0.05	J	0.40	0.29	=	3.57	0.22	J	0.74	0.12	UJ	0.13	0.24	=	1.66	0.34
SU-1	HTR84770	HTR84770	U	0.28	0.28	U	0.84	0.83	=	3.36	0.07	=	0.75	0.09	J	1.47	0.27	=	7.13	0.14	=	1.04	0.27	=	0.44	0.36	=	4.93	0.59
SU-1	HTR84777	HTR84770	UJ	0.04	0.91	UJ	1.45	2.88	=	2.86	0.26	=	0.87	0.34	=	1.13	0.25	=	2.62	0.25	J	0.55	0.14	UJ	0.00	1.14	=	8.24	1.65
SU-1	HTR84771	HTR84771	UJ	0.04	0.28	UJ	0.09	0.75	=	2.47	0.07	=	0.69	0.08	J	1.60	0.51	=	3.06	0.19	=	1.37	0.35	UJ	0.14	0.36	=	2.94	0.51
SU-1	HTR84778	HTR84771	UJ	0.01	0.24	UJ	0.15	0.69	=	2.10	0.07	=	0.58	0.09	=	1.07	0.27	=	2.77	0.15	J	0.60	0.15	UJ	0.02	0.32	=	1.97	0.47
SU-1	HTR84772	HTR84772	UJ	0.02	0.49	U	1.26	1.42	=	6.62	0.12	=	6.36	0.14	=	8.18	0.31	=	7.88	0.28	=	6.02	0.23	UJ	0.10	0.67	=	5.05	0.99
SU-1	HTR84779	HTR84772	=	0.52	0.21	U	0.61	0.62	=	1.67	0.05	=	0.50	0.07	J	0.44	0.25	=	2.28	0.14	J	0.56	0.14	U	0.23	0.29	=	2.99	0.43
SU-1	HTR84773	HTR84773	UJ	0.05	0.23	U	0.52	0.66	=	2.19	0.05	=	0.75	0.07	J	0.79	0.33	=	4.37	0.37	J	0.75	0.27	U	0.30	0.31	=	2.21	0.44
SU-1	HTR84780	HTR84773	=	0.37	0.27	UJ	0.15	0.76	=	2.73	0.07	=	0.58	0.08	J	0.62	0.37	=	5.39	0.33	J	0.65	0.28	UJ	0.25	0.37	=	3.75	0.53
SU-1	HTZ66329	HTZ66329	U	0.68	0.22	U	-0.07	0.85	=	4.11	0.04	=	2.25	0.07	=	2.45	0.21	=	17.30	0.11	=	1.90	0.21	=	0.56	0.19	=	7.19	0.61
SU-1	SLD84111	SLD84111	UJ	-0.06	0.12	UJ	-0.09	0.57	=	1.62	0.05	J	0.34	0.05	J	0.30	0.24	J	0.98	0.20	J	0.39	0.20	UJ	-0.04	0.25	=	1.19	0.22
SU-1	SLD84130	SLD84111	U	0.21	0.21	UJ	-0.19	0.92	=	3.85	0.08	J	0.77	0.09	=	1.23	0.26	=	4.93	0.14	J	0.47	0.14	=	0.66	0.45	=	5.97	0.39
SU-1	SLD84143	SLD84111	UJ	0.04	0.22	UJ	-0.07	0.61	=	1.22	0.05	=	0.21	0.06	J	0.48	0.32	=	1.82	0.28	J	0.24	0.13	UJ	0.05	0.28	J	0.74	0.43
SU-1	SLD84965	SLD84111	UJ	0.45	1.20	UJ	1.61	3.24	=	2.29	0.34	=	1.32	0.31	=	1.39	0.24	=	1.78	0.13	=	0.84	0.13	UJ	0.30	1.38	U	2.48	2.96
SU-1	SLD84112	SLD84112	UJ	0.04	0.09	UJ	-0.03	0.41	=	0.90	0.04	=	0.18	0.04	J	0.43	0.25	J	0.89	0.13	UJ	0.10	0.13	UJ	0.02	0.19	=	0.70	0.16
SU-1	SLD84156	SLD84112	UJ	-0.24	0.18	UJ	0.27	0.87	=	1.43	0.08	=	0.98	0.07	J	1.26	0.13	J	1.15	0.25	=	1.07	0.13	UJ	0.18	0.39	=	2.43	0.30
SU-1	SLD84162	SLD84112	UJ	-0.44	0.50	UJ	-0.57	2.15	=	2.09	0.22	=	1.51	0.23	J	1.48	0.28	J	2.02	0.13	=	1.73	0.13	UJ	-0.13	0.92	U	1.43	1.32
SU-1	SLD84168	SLD84112	UJ	-0.08	0.56	UJ	-0.56	2.72	=	1.74	0.24	=	1.70	0.25	J	1.98	0.13	J	1.79	0.13	=	1.74	0.13	UJ	0.46	1.16	U	2.02	1.56
SU-1	SLD84113	SLD84113	UJ	-0.07	0.46	UJ	0.43	2.22	=	2.10	0.22	=	0.67	0.22	J	0.58	0.16	J	1.39	0.16	J	0.80	0.29	UJ	-0.05	0.97	=	2.06	0.78
SU-1	SLD84131	SLD84113	UJ	-0.04	0.08	UJ	0.08	0.35	=	1.01	0.03	J	0.16	0.02	J	0.40	0.32	J	1.17	0.27	UJ	0.11	0.15	UJ	0.05	0.18	=	0.68	0.13
SU-1	SLD84144	SLD84113	UJ	-0.05	0.15	UJ	0.12	0.68	=	1.19	0.07	J	0.29	0.07	UJ	0.10	0.14	J	0.77	0.14	UJ	0.04	0.26	UJ	0.12	0.34	=	0.73	0.34
SU-1	SLD84972	SLD84113	UJ	0.04	0.12	UJ	-0.04	0.58	=	1.33	0.06	=	0.50	0.05	J	0.88	0.30	J	1.36	0.14	J	0.50	0.14	UJ	0.03	0.26	=	0.97	0.21
SU-1	SLD84115	SLD84115	UJ	0.26	0.40	UJ	0.38	1.91	=	3.63	0.18	=	0.96	0.18	=	1.44	0.32	=	3.38	0.13	J	0.62	0.13	U	0.82	0.97	=	5.51	0.74
SU-1	SLD84133	SLD84115	UJ	-0.06	0.15	UJ	-0.16	0.63	=	2.22	0.06	=	0.82	0.06	J	0.93	0.36	J	2.56	0.13	J	0.79	0.13	UJ	-0.08	0.34	=	1.85	0.29
SU-1	SLD84146	SLD84115	UJ	0.01	0.29	UJ	-0.42	1.61	=	1.71	0.16	=	0.80	0.16	J	0.62	0.13	J	1.57	0.24	J	0.81	0.13	UJ	0.14	0.74	UJ	0.66	1.13
SU-1	SLD84969	SLD84115	UJ	-0.08	0.16	UJ	0.02	0.75	=	1.41	0.07	=	1.26	0.06	=	1.78	0.37	J	2.23	0.26	=	0.92	0.14	UJ	0.03	0.35	=	1.80	0.33
SU-1	SLD84116	SLD84116	UJ	-0.16	0.17	UJ	0.31	0.77	=	1.41	0.06	=	0.46	0.07	J	0.91	0.36	=	1.43	0.19	J	0.64	0.19	UJ	0.15	0.37	=	1.36	0.37
SU-1	SLD84157	SLD84116	UJ	0.01	0.20	UJ	0.34	0.86	=	1.31	0.08	=	0.87	0.08	=	1.25	0.16	=	1.95	0.30	J	0.77	0.16	UJ	0.05	0.42	=	1.18	0.42
SU-1	SLD84163	SLD84116	U	0.16	0.15	UJ	0.24	0.63	=	1.35	0.06	=	0.87	0.06	J	1.47	0.13	=	0.94	0.24	J	0.62	0.13	UJ	0.07	0.31	=	1.34	0.29
SU-1	SLD84169	SLD84116	UJ	-0.12	0.32	UJ	0.39	1.51	=	1.45	0.14	=	1.21	0.16	J	1.09	0.24	=	1.91	0.11	=	1.35	0.11	UJ	-0.37	0.71	=	1.70	0.70
SU-1	SLD84117	SLD84117	UJ	0.02	0.10	UJ	0.10	0.53	=	0.64	0.04	J	0.08	0.04	J	0.28	0.13	J	0.60	0.24	UJ	0.05	0.13	U	0.17	0.22	U	0.63	0.32
SU-1	SLD84134	SLD84117	UJ	0.02	0.23	UJ	0.03	0.92	=	1.55	0.09	=	0.96	0.08	J	0.85	0.24	=	1.17	0.29	J	0.66	0.24	UJ	0.22	0.44	=	1.92	0.44
SU-1	SLD84147	SLD84117	UJ	-0.17	0.22	UJ	0.05	1.01	=	1.51	0.08	=	0.81	0.10	=	1.41	0.32	=	1.33	0.14	=	1.38	0.14	UJ	0.16	0.48	U	0.94	0.64
SU-1	SLD84974	SLD84117	UJ	0.05	0.14	UJ	0.07	0.60	=	3.46	0.05	=	0.46	0.05	J	0.46	0.30	=	2.84	0.12	J	0.59	0.12	UJ	0.14	0.31	=	2.49	0.26
SU-1	SLD84118	SLD84118	UJ	0.08	0.11	UJ	-0.31	0.46	=	1.03	0.04	J	0.16	0.04	J	0.26	0.14	=	1.11	0.14	J	0.16	0.14	UJ	0.04	0.23	=	0.72	0.24
SU-1	SLD84135	SLD84118	UJ	-0.18	0.23	UJ	0.25	0.97	=	2.36	0.09	=	0.85	0.08	J	0.91	0.15	=	1.16	0.27	J	0.37	0.14	UJ	0.18	0.47	=	2.00	0.44
SU-1	SLD84148	SLD84118	UJ	0.07	0.20	UJ	-0.22	0.90	=	1.52	0.07	=	0.62	0.07	J	0.68	0.14	J	0.95	0.14	J	0.68	0.14	UJ	-0.05	0.41	=	1.51	0.39
SU-1	SLD84975	SLD84118	UJ	0.23	0.43	UJ	0.06	1.76	=	3.34	0.17	=	1.63	0.18	J	1.46	0.14	=	2.66	0.25	=	1.51	0.14	UJ	0.32	0.79	=	3.37	0.69
SU-1	SLD84119	SLD84119	UJ	-0.03	0.24	UJ	0.33	0.99	=	2.31	0.09	=	0.76	0.10	=	0.93	0.29	=	2.11	0.29	J	0.84	0.24	UJ	0.03	0.47	=	2.69	0.46

Table A-1. Final Status Survey Soil Sample Data

Survey Unit	Sample Name	Station Name	Ac-227			Pa-231			Ra-226			Ra-228			Th-228			Th-230			Th-232			U-235			U-238		
			VQ[1]	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA
SU-1	SLD84136	SLD84119	UJ	-0.03	0.16	UJ	-0.12	0.68	=	1.19	0.06	=	0.58	0.06	=	0.96	0.34	=	2.29	0.14	J	0.65	0.14	U	0.22	0.34	=	1.04	0.34
SU-1	SLD84149	SLD84119	UJ	-0.32	0.53	UJ	0.29	2.48	=	4.89	0.20	=	1.28	0.25	=	1.47	0.31	=	2.60	0.12	=	0.87	0.12	UJ	-0.25	1.03	=	3.08	1.19
SU-1	SLD84976	SLD84119	UJ	0.21	0.31	UJ	-0.57	1.47	=	2.33	0.13	=	0.85	0.13	J	1.24	0.15	=	2.13	0.28	J	0.84	0.15	UJ	-0.02	0.68	=	1.75	0.68
SU-1	SLD84120	SLD84120	UJ	-0.09	0.22	UJ	0.28	0.88	=	1.83	0.09	=	0.68	0.08	=	1.10	0.25	=	1.97	0.14	=	1.06	0.14	UJ	0.05	0.47	=	1.89	0.43
SU-1	SLD84158	SLD84120	UJ	0.00	0.10	UJ	0.06	0.48	=	1.11	0.04	=	0.39	0.04	J	0.99	0.24	=	0.95	0.24	UJ	0.18	0.24	UJ	-0.07	0.23	=	1.03	0.19
SU-1	SLD84164	SLD84120	UJ	0.02	0.13	UJ	-0.22	0.56	=	1.42	0.05	=	0.73	0.05	J	0.87	0.30	=	1.71	0.12	=	0.81	0.12	UJ	-0.07	0.27	=	1.35	0.24
SU-1	SLD84170	SLD84120	UJ	-0.10	0.14	UJ	-0.17	0.64	=	1.40	0.05	=	0.94	0.06	J	1.06	0.13	=	1.54	0.13	J	0.82	0.13	UJ	-0.02	0.30	=	1.56	0.26
SU-1	SLD84121	SLD84121	U	0.00	0.23	UJ	-0.46	1.26	=	0.97	0.13	=	0.34	0.11	J	0.49	0.13	=	1.16	0.25	J	0.29	0.13	UJ	-0.30	0.51	=	1.13	0.55
SU-1	SLD84137	SLD84121	UJ	-0.18	0.16	UJ	-0.43	0.75	=	2.91	0.07	=	1.07	0.07	=	1.48	0.14	=	2.74	0.27	=	1.32	0.14	U	0.27	0.35	=	3.08	0.33
SU-1	SLD84150	SLD84121	UJ	-0.17	0.32	U	1.92	1.72	=	1.61	0.16	=	1.11	0.15	=	1.16	0.14	=	1.75	0.25	=	1.11	0.14	UJ	0.04	0.76	=	2.95	0.62
SU-1	SLD84977	SLD84121	UJ	-0.12	0.22	U	0.81	1.03	=	1.20	0.07	=	0.93	0.09	=	1.55	0.12	J	1.73	0.12	=	0.87	0.12	UJ	0.17	0.47	U	0.91	0.64
SU-1	SLD84122	SLD84122	UJ	-0.02	0.08	UJ	-0.08	0.39	=	1.06	0.04	=	0.17	0.03	J	0.26	0.14	=	1.07	0.14	J	0.20	0.14	UJ	0.07	0.20	=	0.65	0.18
SU-1	SLD84159	SLD84122	UJ	0.16	0.23	UJ	-0.46	0.89	=	1.34	0.08	=	0.48	0.09	J	0.70	0.31	J	1.21	0.31	J	0.41	0.14	UJ	0.09	0.44	=	1.14	0.44
SU-1	SLD84165	SLD84122	UJ	-0.02	0.23	UJ	0.33	0.99	=	1.76	0.09	=	1.04	0.09	=	1.28	0.25	J	2.12	0.25	=	1.37	0.25	UJ	-0.26	0.43	=	1.75	0.50
SU-1	SLD84171	SLD84122	UJ	0.13	0.54	UJ	-1.64	2.13	=	1.95	0.20	=	0.99	0.21	=	1.16	0.41	J	1.81	0.16	J	0.96	0.16	UJ	0.02	0.98	UJ	0.77	1.52
SU-1	SLD84123	SLD84123	UJ	0.04	0.12	UJ	0.25	0.56	=	1.82	0.04	=	0.52	0.05	J	0.63	0.14	=	1.56	0.26	J	0.47	0.14	UJ	0.10	0.29	=	1.86	0.23
SU-1	SLD84138	SLD84123	UJ	0.12	0.37	UJ	0.65	1.70	=	2.67	0.16	=	0.95	0.15	J	0.64	0.33	=	2.12	0.13	J	0.68	0.13	U	0.69	0.77	=	2.46	0.63
SU-1	SLD84151	SLD84123	UJ	0.23	0.33	UJ	-0.85	1.41	=	2.30	0.15	=	0.74	0.13	J	0.73	0.12	=	2.05	0.23	J	0.46	0.12	UJ	0.05	0.72	=	2.87	0.61
SU-1	SLD84978	SLD84123	UJ	-0.01	0.42	UJ	0.09	1.99	=	1.66	0.17	=	0.92	0.18	=	1.00	0.33	J	1.33	0.13	=	1.28	0.13	UJ	-0.24	0.73	UJ	0.38	1.14
SU-1	SLD84124	SLD84124	UJ	0.00	0.10	UJ	0.01	0.47	=	1.27	0.03	J	0.19	0.04	J	0.49	0.28	J	1.18	0.15	J	0.28	0.15	UJ	0.07	0.22	=	0.95	0.17
SU-1	SLD84139	SLD84124	UJ	0.04	0.19	UJ	0.20	0.87	=	3.35	0.08	=	0.69	0.08	J	0.75	0.26	=	3.11	0.14	J	0.65	0.26	U	0.40	0.43	=	2.85	0.37
SU-1	SLD84152	SLD84124	UJ	-0.01	0.16	UJ	0.22	0.76	=	1.19	0.07	=	0.92	0.07	=	1.87	0.13	J	1.18	0.13	=	1.03	0.13	UJ	0.16	0.34	=	1.40	0.31
SU-1	SLD84979	SLD84124	UJ	-0.07	0.14	UJ	0.09	0.63	=	1.99	0.06	=	0.77	0.06	J	0.51	0.11	=	1.65	0.11	J	0.55	0.11	UJ	0.08	0.31	=	1.65	0.27
SU-1	SLD84125	SLD84125	UJ	-0.08	0.10	UJ	0.16	0.47	=	1.12	0.04	J	0.19	0.05	J	0.49	0.36	J	1.00	0.14	UJ	0.11	0.14	UJ	0.05	0.21	=	1.10	0.23
SU-1	SLD84160	SLD84125	UJ	-0.14	0.46	UJ	0.53	2.57	=	1.43	0.23	U	0.53	0.40	J	0.65	0.34	J	0.97	0.15	J	0.17	0.15	UJ	0.14	0.95	=	2.04	0.92
SU-1	SLD84166	SLD84125	UJ	0.16	0.52	UJ	0.39	2.56	=	3.83	0.25	=	1.19	0.22	=	1.71	0.15	=	3.28	0.34	J	0.97	0.15	UJ	0.03	1.04	=	3.59	0.92
SU-1	SLD84172	SLD84125	UJ	0.09	0.49	UJ	0.26	2.52	=	1.89	0.22	=	1.13	0.24	J	0.98	0.40	J	1.95	0.28	=	1.14	0.15	UJ	-0.25	0.98	UJ	0.67	1.31
SU-1	SLD84126	SLD84126	UJ	0.03	0.11	U	0.36	0.50	=	1.90	0.04	=	0.30	0.04	J	0.76	0.34	=	1.77	0.34	UJ	0.21	0.28	UJ	0.01	0.25	=	1.27	0.21
SU-1	SLD84140	SLD84126	UJ	0.03	0.17	UJ	0.09	0.73	=	2.58	0.06	=	0.90	0.07	=	1.05	0.15	=	2.70	0.15	J	0.72	0.15	UJ	0.02	0.38	=	2.34	0.33
SU-1	SLD84153	SLD84126	UJ	-0.03	0.18	UJ	0.07	0.80	=	1.70	0.07	J	0.38	0.07	J	0.56	0.15	J	2.30	0.15	J	0.28	0.15	UJ	0.35	0.38	=	1.60	0.39
SU-1	SLD84980	SLD84126	UJ	-0.11	0.20	UJ	-0.05	0.92	=	1.65	0.09	=	0.52	0.08	J	0.47	0.14	J	1.41	0.27	J	0.58	0.14	UJ	-0.22	0.41	=	1.41	0.44
SU-1	SLD84127	SLD84127	UJ	0.00	0.12	UJ	0.22	0.53	=	1.36	0.05	=	0.28	0.05	J	0.51	0.37	=	1.93	0.14	J	0.30	0.14	UJ	-0.01	0.27	=	2.24	0.24
SU-1	SLD84141	SLD84127	UJ	-0.17	0.34	UJ	0.07	1.43	=	1.39	0.15	=	0.57	0.16	J	0.66	0.36	J	0.96	0.15	J	0.27	0.15	UJ	0.15	0.76	=	2.33	0.67
SU-1	SLD84154	SLD84127	UJ	-0.23	0.16	UJ	-0.16	0.66	=	0.69	0.06	=	0.49	0.07	J	0.38	0.15	J	1.78	0.27	J	0.65	0.15	U	0.23	0.33	=	1.28	0.31
SU-1	SLD84981	SLD84127	UJ	-0.17	0.24	U	0.82	0.91	=	1.48	0.08	=	0.91	0.10	=	1.41	0.14	J	1.75	0.25	J	0.85	0.14	UJ	-0.19	0.44	=	1.57	0.47
SU-1	SLD84128	SLD84128	UJ	-0.07	0.11	UJ	-0.02	0.47	=	1.30	0.05	J	0.10	0.04	U	0.33	0.36	J	1.94	0.16	UJ	0.12	0.16	UJ	0.07	0.23	=	1.00	0.19
SU-1	SLD84142	SLD84128	U	0.16	0.13	UJ	-0.03	0.57	=	1.97	0.05	J	0.30	0.05	U	0.38	0.40	=	2.75	0.15	J	0.62	0.32	UJ	0.28	0.29	=	2.00	0.22
SU-1	SLD84155	SLD84128	UJ	0.18	0.44	UJ	-0.21	2.07	=	2.28	0.19	=	0.85	0.18	J	1.08	0.37	J	2.57	0.31	J	0.37	0.17	UJ	0.16	0.90	=	2.36	0.87
SU-1	SLD84982	SLD84128	UJ	0.02	0.14	UJ	0.09	0.60	=	2.21	0.05	=	0.54	0.06	J	0.74	0.31	=	2.19	0.26	J	0.77	0.14	UJ	0.18	0.31	=	1.81	0.26
SU-1	SLD84129	SLD84129	UJ	-0.05	0.06	UJ	0.03	0.31	=	0.53	0.02	U	0.03	0.04	UJ	0.22	0.30	J	0.68	0.35	UJ	0.04	0.30	UJ	-0.07	0.14	=	0.51	0.12
SU-1	SLD84161	SLD84129	UJ	-0.53	0.53	UJ	-1.44	2.48	=	4.93	0.20	=	1.77	0.22	=	1.81	0.27	=	3.32	0.12	=	1.34	0.12	UJ	0.10	1.08	U	2.08	1.64
SU-1	SLD84167	SLD84129	UJ	0.08	0.42	UJ	-1.81	2.02	=	2.00	0.19	=	0.67	0.24	=	1.09	0.14	J	1.70	0.26	J	0.88	0.14	UJ	0.27	0.97	=	2.38	1.02
SU-1	SLD84173	SLD84129	UJ	0.01	0.21	UJ	0.35	0.93	=	1.33	0.08	=	0.85	0.07	=	0.87	0.26	J	1.45	0.12	J	0.55	0.12	UJ	0.05	0.41	=	1.51	0.42
SU-1	SLD84696	SLD84696	U	0.36	0.19	U	0.59	0.83	=	4.70	0.07	J	0.56	0.07	=	1.09	0.30	=	3.69	0.26	J	0.66	0.14	=	0.47	0.40	=	5.72	0.35

Table A-1. Final Status Survey Soil Sample Data

Survey Unit	Sample Name	Station Name	Ac-227			Pa-231			Ra-226			Ra-228			Th-228			Th-230			Th-232			U-235			U-238		
			VQ[1]	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA
SU-1	SLD84697	SLD84696	UJ	-0.04	0.17	UJ	-0.40	0.74	=	2.68	0.07	J	0.76	0.07	J	0.70	0.24	=	2.55	0.13	J	0.55	0.24	UJ	0.11	0.37	=	2.29	0.34
SU-1	SLD84698	SLD84696	UJ	-0.01	0.14	UJ	-0.10	0.60	=	1.26	0.06	J	0.71	0.06	=	1.12	0.39	J	1.38	0.14	J	0.88	0.32	U	0.28	0.30	=	1.44	0.27
SU-1	SLD84699	SLD84696	UJ	-0.04	0.13	UJ	0.09	0.57	=	1.26	0.06	J	0.76	0.06	=	1.62	0.15	J	1.79	0.15	=	1.17	0.15	UJ	0.08	0.28	=	1.42	0.25
SU-1	SLD84700	SLD84700	=	0.40	0.19	UJ	0.18	1.00	=	5.19	0.09	J	1.90	0.09	=	2.11	0.31	=	5.20	0.26	=	1.72	0.14	U	0.56	0.51	=	6.66	0.42
SU-1	SLD84701	SLD84700	U	0.28	0.19	U	0.45	0.67	=	1.94	0.06	J	0.52	0.06	J	0.79	0.29	=	2.38	0.13	J	0.43	0.13	U	0.42	0.34	=	3.68	0.28
SU-1	SLD84702	SLD84700	UJ	-0.08	0.11	UJ	-0.09	0.46	=	1.19	0.05	J	0.41	0.05	J	0.66	0.14	J	1.49	0.30	J	0.40	0.14	U	0.15	0.24	=	1.74	0.18
SU-1	SLD84703	SLD84700	UJ	0.00	0.14	UJ	0.31	0.64	=	1.21	0.06	J	0.87	0.06	J	0.81	0.33	J	1.30	0.23	=	0.99	0.12	UJ	0.10	0.30	=	1.82	0.24
SU-1	SLD87644	SLD87644	UJ	0.00	0.33	UJ	0.60	0.96	=	3.69	0.09	=	1.32	0.11	=	1.28	0.17	=	2.81	0.17	=	1.53	0.17	UJ	0.03	0.43	=	3.10	0.64
SU-1	SLD87645	SLD87645	UJ	0.68	0.31	U	0.79	0.87	=	5.05	0.08	=	0.86	0.10	=	1.61	0.15	=	4.05	0.15	=	1.22	0.15	J	0.41	0.41	=	5.30	0.60
SU-1	SLD87646	SLD87645	UJ	0.02	0.31	UJ	0.21	0.86	=	3.76	0.08	=	0.84	0.10	=	1.76	0.37	=	3.25	0.37	J	1.32	0.37	UJ	0.07	0.40	=	2.36	0.60
SU-1	SLD92878	SLD92878	UJ	0.21	0.37	UJ	0.00	0.95	=	2.38	0.09	=	0.90	0.12	J	0.66	0.42	J	1.94	0.68	J	1.05	0.19	UJ	0.08	0.46	J	1.87	1.22
SU-1	SLD92879	SLD92878	UJ	0.14	0.34	UJ	0.22	0.85	=	3.18	0.081	=	0.61	0.10	J	0.88	0.25	=	2.67	0.25	J	0.74	0.13	UJ	0.09	0.43	J	1.99	1.04
SU-1	SLD92880	SLD92880	UJ	0.18	0.33	UJ	-0.27	0.83	=	1.47	0.078	=	0.59	0.11	=	0.89	0.13	J	1.60	0.13	J	0.52	0.13	UJ	0.08	0.43	=	2.19	1.01
SU-1	SLD92881	SLD92880	U	0.21	0.28	UJ	0.17	0.76	=	1.34	0.074	=	0.54	0.10	J	0.57	0.27	J	1.60	0.12	J	0.59	0.12	UJ	0.09	0.36	=	2.36	0.93
SU-1	SLD92882	SLD92882	UJ	-0.08	0.27	UJ	-0.15	0.77	=	1.28	0.071	=	0.62	0.10	J	0.49	0.23	J	0.99	0.28	=	0.91	0.23	UJ	0.08	0.37	J	1.92	0.94
SU-1	SLD92883	SLD92882	UJ	-0.01	0.31	UJ	0.35	0.84	=	1.07	0.086	=	0.80	0.11	=	1.55	0.31	J	1.43	0.14	=	1.36	0.26	UJ	0.02	0.42	U	0.75	1.25
SU-2	HTZ66228	HTZ66228	U	0.06	0.21	U	0.09	0.96	=	3.30	0.05	=	0.81	0.08	=	1.52	0.29	=	3.60	0.24	=	1.44	0.13	U	0.33	0.23	=	3.51	1.15
SU-2	HTZ66231	HTZ66231	U	0.12	0.16	U	0.46	0.75	=	2.52	0.04	=	0.68	0.06	J	0.75	0.31	=	4.38	0.14	J	0.93	0.14	J	0.24	0.15	=	2.66	0.50
SU-2	HTZ66324	HTZ66324	=	0.14	0.11	U	0.30	0.56	=	2.10	0.03	=	0.85	0.05	=	1.92	0.29	=	3.11	0.24	=	1.15	0.12	J	0.16	0.12	=	2.22	0.39
SU-2	HTZ66325	HTZ66325	U	0.12	0.08	U	0.12	0.35	=	0.37	0.02	=	0.35	0.03	J	0.37	0.32	=	0.96	0.11	J	0.37	0.11	U	0.03	0.07	J	0.28	0.25
SU-2	HTZ66326	HTZ66326	U	0.15	0.18	U	0.62	0.78	=	2.63	0.05	=	1.02	0.06	=	1.65	0.23	=	3.51	0.12	=	0.93	0.12	=	0.34	0.16	=	5.60	0.55
SU-2	HTZ66327	HTZ66326	U	0.22	0.18	U	0.17	0.74	=	1.92	0.05	=	0.98	0.07	=	1.15	0.11	=	2.50	0.20	=	1.18	0.11	=	0.32	0.16	=	4.55	0.51
SU-2	HTZ66328	HTZ66328	U	0.04	0.08	U	-0.22	0.33	=	0.36	0.02	=	0.23	0.03	=	1.98	0.20	=	1.41	0.11	=	1.84	0.11	U	0.02	0.07	=	0.49	0.24
SU-2	HTZ68154	HTZ68154	U	0.98	0.20	UJ	0.46	0.73	=	1.71	0.04	=	1.55	0.06	=	3.95	0.33	=	4.18	0.15	=	3.39	0.28	UJ	0.10	0.16	=	1.83	1.59
SU-2	HTZ68155	HTZ68154	U	0.23	0.10	UJ	0.12	0.43	=	0.50	0.02	=	0.37	0.04	J	0.36	0.23	J	0.61	0.13	UJ	0.09	0.13	U	0.09	0.09	UJ	0.29	0.96
SU-2	HTZ68160	HTZ68160	U	0.23	0.20	UJ	0.16	0.87	=	2.68	0.08	=	0.51	0.07	J	0.97	0.39	=	4.87	0.14	J	0.63	0.14	U	0.20	0.20	=	2.24	1.04
SU-2	HTZ68161	HTZ68161	U	0.66	0.21	U	0.74	0.80	=	3.03	0.04	=	0.91	0.06	=	1.29	0.29	=	4.35	0.24	J	0.72	0.13	U	0.25	0.19	=	3.65	1.83
SU-2	HTZ68162	HTZ68161	U	0.52	0.20	UJ	0.12	0.76	=	1.39	0.04	=	0.75	0.06	=	2.51	0.35	=	6.65	0.14	J	0.94	0.14	U	0.15	0.18	=	2.83	1.67
SU-2	HTZ68163	HTZ68163	UJ	0.04	0.11	UJ	0.12	0.50	=	0.78	0.05	=	0.31	0.05	J	0.61	0.31	J	0.67	0.17	UJ	0.12	0.17	UJ	0.00	0.11	UJ	0.13	0.65
SU-2	HTZ70844	HTZ70844	U	0.24	0.27	UJ	0.34	1.20	=	5.62	0.10	=	1.17	0.10	J	1.27	0.32	=	4.69	0.15	=	1.13	0.15	U	0.57	0.59	=	3.07	1.47
SU-2	HTZ70845	HTZ70845	U	0.27	0.15	UJ	0.28	0.62	=	3.59	0.06	=	0.80	0.06	=	1.55	0.30	=	4.39	0.16	J	1.02	0.16	U	0.18	0.31	=	2.57	0.45
SU-2	HTZ70846	HTZ70846	U	0.35	0.20	UJ	0.42	0.81	=	6.28	0.06	=	1.30	0.07	=	1.98	0.30	=	5.46	0.30	J	1.08	0.16	U	0.49	0.41	=	4.54	0.57
SU-2	HTZ70847	HTZ70847	UJ	0.07	0.12	UJ	-0.12	0.49	=	1.24	0.05	=	0.64	0.05	J	0.89	0.25	J	0.80	0.14	=	1.15	0.14	UJ	-0.08	0.22	J	0.91	0.34
SU-2	HTZ76803	HTZ76803	U	0.33	0.20	UJ	0.26	0.85	=	3.81	0.07	=	1.15	0.07	J	1.20	0.45	=	3.33	0.39	J	1.43	0.45	UJ	0.19	0.40	=	3.47	0.34
SU-2	HTZ76804	HTZ76804	UJ	0.11	0.13	U	0.95	0.58	=	1.17	0.05	=	0.44	0.05	J	0.48	0.33	=	1.74	0.19	J	0.28	0.19	UJ	0.12	0.27	=	1.13	0.22
SU-2	HTZ76854	HTZ76854	UJ	-0.03	0.10	UJ	0.06	0.40	=	1.04	0.04	J	0.43	0.04	J	0.73	0.25	J	1.12	0.11	J	0.37	0.11	=	0.33	0.20	=	4.72	0.20
SU-2	SLD06183	SLD06183	U	0.10	0.23	U	-0.06	0.95	=	1.90	0.06	=	0.76	0.09	J	0.86	0.33	=	2.70	0.15	J	0.66	0.15	U	0.20	0.23	U	2.34	4.57
SU-2	SLD06184	SLD06184	U	0.04	0.25	U	-0.02	1.13	=	2.94	0.07	=	0.83	0.11	=	1.45	0.35	=	3.47	0.19	J	1.23	0.35	J	0.28	0.25	U	4.25	4.51
SU-2	SLD06207	SLD06183	U	0.06	0.19	U	0.09	0.85	=	1.78	0.06	=	0.80	0.08	U	0.52	0.59	=	3.68	0.34	J	0.89	0.25	U	0.04	0.20	U	2.70	3.91
SU-2	SLD06208	SLD06184	U	0.07	0.18	U	-0.18	0.87	=	1.22	0.10	=	0.68	0.08	=	1.03	0.32	=	2.58	0.14	=	1.79	0.14	U	0.16	0.20	U	1.79	4.48
SU-2	SLD72609	SLD72609	U	0.12	0.15	UJ	0.04	0.64	=	2.38	0.06	=	0.94	0.06	=	1.13	0.34	J	1.93	0.30	=	1.09	0.25	U	0.22	0.31	=	2.08	0.47
SU-2	SLD72610	SLD72609	UJ	0.09	0.16	UJ	0.36	0.74	=	2.04	0.07	=	1.25	0.07	=	1.50	0.28	J	2.61	0.15	=	1.55	0.15	UJ	0.02	0.33	=	0.93	0.52
SU-2	SLD72611	SLD72609	UJ	0.03	0.18	UJ	0.24	0.82	=	2.14	0.08	=	1.16	0.08	=	1.72	0.42	J	1.65	0.27	=	1.29	0.15	UJ	0.02	0.36	J	1.02	0.56
SU-2	SLD81701	SLD80701	UJ	-0.04	0.12	UJ	0.16	0.47	=	1.18	0.04	=	0.59	0.04	J	0.66	0.26	J	1.58	0.26	J	0.62	0.14	UJ	-0.02	0.22	=	1.04	0.20

Table A-1. Final Status Survey Soil Sample Data

Survey			Ac-227			Pa-231			Ra-226			Ra-228			Th-228			Th-230			Th-232			U-235			U-238		
Unit	Sample Name	Station Name	VQ[1]	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA
SU-2	SLD81702	SLD80701	UJ	-0.07	0.13	UJ	0.23	0.54	=	1.29	0.05	=	0.66	0.05	J	0.86	0.24	J	2.24	0.24	J	0.67	0.13	UJ	-0.12	0.24	=	1.11	0.22
SU-2	SLD81673	SLD81673	UJ	0.03	0.13	UJ	-0.04	0.56	=	1.04	0.05	=	0.46	0.05	J	0.59	0.30	J	0.74	0.22	J	0.49	0.12	UJ	0.06	0.29	=	1.14	0.30
SU-2	SLD81674	SLD81673	UJ	0.03	0.15	UJ	0.14	0.69	=	0.87	0.06	=	0.51	0.06	J	0.76	0.15	=	1.39	0.27	J	0.80	0.27	UJ	-0.01	0.29	=	1.02	0.29
SU-2	SLD81675	SLD81673	UJ	0.02	0.18	UJ	0.34	0.80	=	1.53	0.07	=	0.70	0.07	=	1.31	0.32	=	2.39	0.13	J	0.52	0.13	UJ	0.01	0.37	=	1.66	0.38
SU-2	SLD81676	SLD81673	UJ	0.09	0.20	UJ	-0.07	0.76	=	1.46	0.08	=	0.89	0.07	=	1.62	0.29	=	1.73	0.13	=	0.86	0.13	UJ	0.08	0.40	=	1.45	0.41
SU-2	SLD81679	SLD81679	UJ	0.15	0.22	UJ	-0.78	0.92	=	3.78	0.08	=	0.81	0.08	=	1.34	0.14	=	3.13	0.14	=	0.97	0.14	U	0.48	0.48	=	3.32	0.47
SU-2	SLD81680	SLD81679	UJ	0.05	0.20	UJ	-0.18	0.80	=	1.35	0.07	=	0.74	0.08	=	1.24	0.34	=	2.73	0.26	J	0.86	0.14	UJ	-0.01	0.40	=	1.35	0.39
SU-2	SLD81707	SLD81679	UJ	-0.25	0.19	UJ	-0.26	0.77	=	1.36	0.07	=	0.93	0.07	=	1.56	0.38	=	3.35	0.17	J	0.95	0.17	UJ	0.00	0.38	=	1.33	0.41
SU-2	SLD81708	SLD81679	UJ	0.00	0.19	UJ	-0.05	0.78	=	1.33	0.07	=	0.93	0.08	=	1.57	0.27	=	2.92	0.40	=	1.03	0.15	UJ	0.09	0.38	UJ	0.07	0.53
SU-2	SLD81681	SLD81681	UJ	-0.09	0.10	UJ	-0.06	0.41	=	1.19	0.04	=	0.43	0.04	J	0.54	0.11	J	0.95	0.11	J	0.50	0.11	UJ	-0.06	0.22	=	1.67	0.21
SU-2	SLD81682	SLD81681	UJ	0.00	0.14	UJ	0.31	0.57	=	1.33	0.05	=	1.01	0.05	=	1.14	0.25	J	0.98	0.25	J	0.84	0.14	UJ	0.10	0.29	=	1.57	0.27
SU-2	SLD81683	SLD81683	UJ	0.10	0.20	UJ	-0.08	0.78	=	1.57	0.08	=	0.80	0.07	=	0.93	0.30	=	2.11	0.14	=	1.10	0.14	UJ	0.21	0.40	=	2.19	0.41
SU-2	SLD81684	SLD81683	UJ	-0.08	0.20	UJ	0.02	0.79	=	1.78	0.07	=	0.65	0.07	J	0.76	0.26	=	2.66	0.14	=	0.97	0.14	UJ	-0.01	0.37	=	1.79	0.38
SU-2	SLD81685	SLD81683	UJ	0.00	0.19	UJ	0.12	0.81	=	2.48	0.07	=	0.70	0.07	J	0.93	0.29	=	2.59	0.29	J	0.48	0.13	UJ	0.19	0.37	=	2.23	0.29
SU-2	SLD81686	SLD81683	UJ	0.14	0.45	UJ	0.78	2.29	=	3.74	0.20	=	0.97	0.18	J	0.76	0.23	=	3.18	0.12	J	0.73	0.12	U	0.65	0.92	J	2.12	0.82
SU-2	SLD81687	SLD81687	UJ	-0.02	0.13	UJ	0.32	0.58	=	1.28	0.05	=	0.99	0.05	=	1.19	0.32	J	2.01	0.13	=	0.94	0.13	UJ	0.11	0.29	=	1.66	0.27
SU-2	SLD81688	SLD81687	U	0.10	0.11	UJ	0.16	0.50	=	1.08	0.04	=	0.86	0.05	=	1.09	0.36	J	1.87	0.15	=	1.11	0.27	UJ	0.03	0.24	=	1.24	0.22
SU-2	SLD81689	SLD81689	UJ	-0.08	0.13	UJ	0.06	0.55	=	1.34	0.05	=	0.68	0.05	J	1.07	0.23	=	2.38	0.23	J	0.72	0.12	UJ	0.16	0.26	=	1.41	0.23
SU-2	SLD81690	SLD81689	UJ	0.07	0.16	UJ	0.11	0.63	=	1.44	0.05	=	0.83	0.06	J	0.70	0.21	J	1.54	0.21	=	0.88	0.11	UJ	0.22	0.30	=	1.65	0.25
SU-2	SLD82247	SLD81689	UJ	-0.07	0.10	UJ	0.14	0.41	=	0.91	0.04	=	0.60	0.04	=	1.11	0.29	=	1.03	0.13	J	0.44	0.13	UJ	-0.11	0.19	=	1.12	0.17
SU-2	SLD82248	SLD81689	UJ	0.03	0.16	UJ	0.16	0.57	=	1.27	0.05	=	0.92	0.05	=	1.56	0.27	=	1.35	0.40	=	1.08	0.15	UJ	0.08	0.26	=	1.40	0.22
SU-2	SLD81691	SLD81691	UJ	-0.02	0.10	UJ	0.05	0.45	=	0.90	0.04	=	0.65	0.04	J	0.53	0.13	J	1.24	0.13	=	1.17	0.24	U	0.15	0.21	=	1.18	0.20
SU-2	SLD81692	SLD81691	UJ	-0.02	0.09	UJ	0.11	0.39	=	0.69	0.03	=	0.49	0.04	J	0.83	0.28	J	0.70	0.24	J	0.52	0.13	UJ	0.00	0.19	=	0.87	0.18
SU-2	SLD81693	SLD81691	U	0.12	0.08	UJ	0.14	0.33	=	0.68	0.03	=	0.40	0.03	J	0.72	0.24	J	1.35	0.13	UJ	0.22	0.29	UJ	0.05	0.17	=	0.60	0.15
SU-2	SLD81694	SLD81691	UJ	-0.06	0.10	U	0.35	0.49	=	0.89	0.03	=	0.36	0.04	J	0.38	0.27	J	0.73	0.27	J	0.31	0.12	UJ	-0.04	0.22	=	0.82	0.19
SU-2	SLD81695	SLD81695	UJ	0.18	0.13	UJ	0.21	0.58	=	1.35	0.05	=	0.79	0.05	=	1.29	0.38	=	2.06	0.32	J	0.80	0.32	UJ	0.14	0.27	=	1.54	0.24
SU-2	SLD81696	SLD81695	UJ	0.00	0.14	UJ	0.02	0.63	=	1.66	0.06	=	0.93	0.06	=	0.93	0.06	UJ	2.71	4.55	=	0.93	0.06	UJ	0.13	0.29	=	1.57	0.24
SU-2	SLD81697	SLD81697	UJ	-0.02	0.10	UJ	-0.04	0.43	=	1.03	0.04	=	0.62	0.03	J	0.59	0.23	J	1.38	0.13	=	1.06	0.13	UJ	0.11	0.21	=	0.97	0.20
SU-2	SLD81698	SLD81697	U	0.15	0.15	UJ	0.18	0.61	=	1.39	0.05	=	0.98	0.05	=	1.64	0.16	J	1.81	0.16	J	0.87	0.29	UJ	-0.06	0.27	=	1.34	0.25
SU-2	SLD81699	SLD81697	UJ	-0.07	0.15	U	0.55	0.61	=	1.42	0.05	=	0.97	0.05	=	1.49	0.32	=	2.56	0.32	=	1.29	0.15	UJ	0.08	0.27	=	1.41	0.23
SU-2	SLD81700	SLD81697	UJ	0.01	0.14	UJ	0.24	0.53	=	1.32	0.05	=	0.82	0.05	=	1.24	0.25	J	1.44	0.14	=	0.99	0.14	UJ	0.05	0.25	=	1.01	0.22
SU-2	SLD81703	SLD81703	UJ	-0.04	0.06	UJ	0.15	0.29	=	0.72	0.02	J	0.11	0.02	J	0.39	0.22	J	0.74	0.22	J	0.26	0.12	UJ	0.04	0.14	=	0.47	0.15
SU-2	SLD81704	SLD81703	UJ	-0.08	0.10	UJ	-0.04	0.46	=	0.70	0.04	J	0.30	0.04	J	0.45	0.32	J	0.83	0.27	J	0.42	0.14	UJ	0.03	0.22	=	0.66	0.21
SU-2	SLD81709	SLD81709	UJ	0.09	0.11	UJ	-0.02	0.47	=	1.14	0.04	=	0.60	0.04	J	0.84	0.30	=	1.27	0.14	J	0.66	0.14	UJ	0.04	0.23	=	1.32	0.18
SU-2	SLD81710	SLD81709	UJ	0.00	0.11	UJ	0.30	0.48	=	0.92	0.04	=	0.58	0.04	=	1.51	0.27	=	1.46	0.15	=	1.05	0.32	UJ	0.16	0.23	=	1.03	0.19
SU-2	SLD81711	SLD81711	UJ	0.10	0.14	UJ	0.24	0.63	=	1.83	0.05	=	0.79	0.05	=	1.33	0.25	=	2.26	0.25	J	0.78	0.25	UJ	0.02	0.28	=	1.85	0.25
SU-2	SLD81712	SLD81711	UJ	0.08	0.17	UJ	0.12	0.69	=	1.57	0.07	=	1.13	0.06	=	2.32	0.31	=	2.27	0.26	=	1.09	0.14	UJ	0.03	0.33	=	1.66	0.27
SU-2	SLD83585	SLD83585	UJ	0.04	0.14	UJ	0.08	0.52	=	2.15	0.05	=	0.75	0.05	J	1.12	0.33	=	2.40	0.28	J	0.92	0.28	UJ	0.21	0.28	=	2.07	0.25
SU-2	SLD83586	SLD83586	UJ	-0.05	0.12	UJ	0.02	0.46	=	1.05	0.04	=	0.75	0.04	J	1.74	0.14	=	2.34	0.26	=	1.08	0.34	UJ	0.01	0.23	=	1.05	0.21
SU-2	SLD84268	SLD84268	UJ	-0.06	0.46	UJ	0.63	2.08	=	2.62	0.18	J	1.07	0.21	=	1.17	0.30	J	2.50	0.16	J	1.07	0.16	UJ	0.22	0.89	=	2.46	0.75
SU-2	SLD84273	SLD84268	UJ	0.09	0.43	UJ	-0.62	2.18	=	1.83	0.20	J	1.34	0.20	=	1.74	0.33	J	2.08	0.13	=	1.34	0.13	UJ	0.27	0.91	UJ	0.26	1.30
SU-2	SLD84277	SLD84268	UJ	-0.09	0.17	UJ	0.20	0.78	=	1.75	0.07	J	1.05	0.07	=	1.14	0.40	J	2.28	0.15	=	1.30	0.15	UJ	0.04	0.35	=	1.77	0.42
SU-2	SLD84966	SLD84268	UJ	0.13	0.25	UJ	-0.09	1.15	=	1.87	0.10	=	1.22	0.11	=	1.73	0.29	=	2.29	0.13	=	1.51	0.13	UJ	0.09	0.51	=	1.91	0.52
SU-2	SLD84269	SLD84269	UJ	-0.08	0.30	UJ	0.14	0.88	=	1.62	0.09	=	0.67	0.10	J	0.38	0.25	=	1.10	0.29	J	0.43	0.25	UJ	-0.02	0.43	U	1.05	1.12

Table A-1. Final Status Survey Soil Sample Data

Survey Unit	Sample Name	Station Name	Ac-227			Pa-231			Ra-226			Ra-228			Th-228			Th-230			Th-232			U-235			U-238		
			VQ[1]	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA
SU-2	SLD84281	SLD84269	UJ	-0.345	0.851	UJ	0.182	2.44	=	2.2	0.227	=	1.31	0.342	=	1 58	0.3	=	1.78	0.301	=	1.48	0.3	UJ	-0.608	0.894	UJ	0.376	3.27
SU-2	SLD84282	SLD84269	UJ	0.10	0.37	UJ	-1.65	1.89	=	2.96	0.17	=	1.10	0.17	=	1.15	0.26	J	1.98	0.14	J	0.80	0.26	UJ	0.60	0.87	=	2.60	0.82
SU-2	SLD84283	SLD84269	UJ	-0.21	0.32	UJ	0.48	1.65	=	1.88	0.14	=	1.21	0.13	J	0.80	0.39	J	2.13	0.14	=	1.41	0.32	UJ	-0.17	0.69	=	2.12	0.67
SU-2	SLD84270	SLD84270	UJ	-0.08	0.22	UJ	-0.02	0.72	=	0.95	0.06	J	0.20	0.06	J	0.28	0.15	J	1.26	0.28	J	0.17	0.15	UJ	0.08	0.33	=	0.68	0.46
SU-2	SLD84274	SLD84270	UJ	-0.03	0.26	UJ	0.04	0.71	=	1.01	0.08	J	0.18	0.07	U	0.00	0.24	J	1.35	0.24	U	0.00	0.24	UJ	-0.12	0.31	=	0.63	0.45
SU-2	SLD84967	SLD84270	UJ	0.13	0.60	UJ	0.96	1.84	=	1.97	0.16	UJ	0.07	0.23	J	0.32	0.11	=	1.27	0.11	J	0.20	0.11	UJ	0.02	0.65	=	1.44	1.04
SU-2	SLD84271	SLD84271	UJ	0.25	0.44	UJ	-0.32	1.01	=	2.06	0.11	=	0.76	0.10	J	0.66	0.26	J	1.87	0.14	=	1.24	0.14	UJ	-0.11	0.48	=	1.26	0.81
SU-2	SLD84275	SLD84271	UJ	0.02	0.37	UJ	-0.01	1.02	=	1.28	0.11	=	0.58	0.09	J	0.74	0.12	J	0.83	0.12	J	0.48	0.12	UJ	0.10	0.50	=	1.01	0.75
SU-2	SLD84279	SLD84271	UJ	0.38	0.90	UJ	0.64	2.71	=	1.35	0.23	J	0.72	0.27	=	0.84	0.26	J	1.03	0.12	=	0.77	0.12	UJ	0.37	1.17	U	2.01	2.35
SU-2	SLD84272	SLD84272	UJ	0.08	0.19	UJ	0.05	0.78	=	2.26	0.06	=	0.49	0.07	J	0.54	0.36	=	1.90	0.25	J	0.39	0.13	UJ	0.15	0.40	=	1.89	0.39
SU-2	SLD84276	SLD84272	UJ	0.33	0.37	UJ	0.26	1.82	=	1.38	0.16	=	1.05	0.16	J	0.79	0.33	=	1.34	0.27	=	1.07	0.27	UJ	-0.25	0.77	=	2.05	0.84
SU-2	SLD84280	SLD84272	UJ	0.11	0.36	UJ	-1.27	1.56	=	1.23	0.13	=	0.65	0.15	J	0.60	0.24	=	1.67	0.24	J	0.65	0.13	UJ	0.19	0.73	UJ	1.02	1.04
SU-2	SLD84971	SLD84272	U	0.29	0.22	UJ	0.24	0.91	=	1.34	0.09	=	0.97	0.08	=	1.08	0.26	=	1.76	0.12	=	1.32	0.12	UJ	0.01	0.44	=	1.46	0.51
SU-2	SLD85142	SLD85142	UJ	0.01	0.11	UJ	0.14	0.29	=	1.05	0.03	=	0.07	0.02	J	0.15	0.13	J	1.06	0.25	UJ	0.04	0.25	UJ	0.02	0.15	=	0.69	0.24
SU-2	SLD85143	SLD85142	UJ	0.06	0.16	UJ	0.11	0.39	=	1.52	0.04	=	0.41	0.04	J	0.46	0.42	J	2.05	0.29	J	0.50	0.29	UJ	-0.05	0.21	=	1.46	0.34
SU-2	SLD85144	SLD85142	UJ	0.03	0.21	UJ	-0.13	0.57	=	1.53	0.06	=	0.92	0.05	=	1.35	0.24	J	1.89	0.13	J	0.79	0.24	UJ	0.06	0.28	=	1.21	0.49
SU-2	SLD85145	SLD85142	UJ	0.00	0.21	UJ	-0.04	0.54	=	1.38	0.05	=	0.74	0.05	=	1.07	0.13	J	2.27	0.29	J	0.58	0.13	UJ	0.01	0.28	=	1.39	0.46
SU-2	SLD85146	SLD85146	UJ	-0.03	0.10	UJ	0.01	0.27	=	0.88	0.03	J	0.09	0.02	J	0.38	0.13	J	1.21	0.29	UJ	0.12	0.28	UJ	-0.03	0.13	=	0.51	0.22
SU-2	SLD85147	SLD85146	U	0.22	0.27	UJ	0.10	0.70	=	3.39	0.07	=	1.20	0.06	=	2.64	0.27	=	2.66	0.14	=	1.53	0.27	UJ	-0.16	0.36	=	2.65	0.60
SU-2	SLD85148	SLD85146	U	0.25	0.36	UJ	0.53	1.02	=	7.52	0.09	=	0.86	0.09	=	1.36	0.16	=	6.25	0.40	J	1.01	0.16	UJ	0.10	0.50	=	5.25	0.79
SU-2	SLD85149	SLD85146	UJ	0.04	0.23	UJ	0.17	0.60	=	1.67	0.05	=	1.07	0.05	=	1.63	0.31	J	2.21	0.31	=	1.45	0.14	UJ	0.11	0.30	J	0.93	0.53
SU-2	SLD87647	SLD87647	UJ	-0.08	0.35	UJ	0.32	0.97	=	5.02	0.09	=	1.04	0.12	=	1.24	0.44	=	5.11	0.36	J	0.63	0.30	U	0.40	0.48	=	5.47	0.67
SU-2	SLD87648	SLD87647	UJ	0.29	0.33	U	1.59	1.02	=	2.62	0.10	=	0.82	0.11	=	1.50	0.35	=	4.01	0.40	J	1.06	0.16	UJ	0.12	0.40	=	1.74	0.58
SU-2	SLD87649	SLD87649	UJ	-0.31	0.30	UJ	0.47	0.97	=	2.08	0.09	=	0.78	0.11	=	2.37	0.18	=	2.90	0.18	=	1.51	0.18	UJ	0.05	0.38	=	1.49	0.60

1 - Validation qualifiers (VQ) are defined as follows:

"=" Positive Result.

"U" When the material was analyzed for, but not detected above the level of the associated value.

"J" When the associated value is an estimated quantity. Indicating there is cause to question accuracy or precision of the reported value.

"UJ" When the analyte was analyzed for, but not detected, above the associated value, however, the reported value is an estimate and demonstrates a decreased knowledge of its accuracy or precision.

"R" When the analyte value reported is unusable. The integrity of the analyte's identification, accuracy, precision, or sensitivity has raised significant question as to the reality of the information presented.

ATTACHMENT B

QUALITY CONTROL SUMMARY REPORT

QUALITY CONTROL SUMMARY REPORT

B-1.1 INTRODUCTION

B-1.1.1 Project Description

Class 2 and 3 FSS sampling was conducted for VPs West of Broadway VPs, Mallinckrodt Plants 3, 8, 9, 11, and Parking Lots at the SLDS. Sampling was conducted in accordance with MARSSIM protocols and the FSSP (USACE 2002).

B-1.1.2 Project Objectives

The intent of the FSS was to evaluate whether each SU satisfies concentration-based and dose-based criteria as defined in the SLDS ROD.

B-1.1.3 Project Implementation

The sampling was conducted from November 2003 through January 2006. Radiological analyses were conducted by the onsite FUSRAP laboratory at the HISS with QA split samples being analyzed by Severn-Trent Laboratories.

B-1.1.4 Purpose of this Report

The primary intent of this assessment is to illustrate that data generated for this sampling can withstand scientific scrutiny, are appropriate for their intended purpose, are technically defensible, and are of known and acceptable sensitivity, precision, and accuracy.

B-1.2 QUALITY ASSURANCE PROGRAM

A quality assurance project plan (QAPP) was developed for this project and is part of the SAG (USACE 2000) for the St. Louis Sites. The QAPP established requirements for both field and laboratory QC procedures. In general, analytical laboratory QC duplicates, matrix spikes, laboratory control samples, and method blanks were required for every 20 field samples of each matrix and analyte.

A primary goal of the QA program was to ensure that the quality of results for environmental measurements was appropriate for their intended use. To this end, a QAPP and standardized field procedures were compiled to guide the investigation. Through the process of readiness review, training, equipment calibration, QC implementation, and detailed documentation, the project has successfully accomplished the goals set by the QA Program.

EPA "definitive" data has been reported including the following basic information as applicable:

a. laboratory case narratives
b. sample results
c. laboratory method blank results
d. laboratory control standard results
e. laboratory sample matrix spike recoveries
f. laboratory duplicate results
g. surrogate recoveries
h. sample extraction dates
i. sample analysis dates

This information from the laboratory, along with field information, provides the basis for subsequent data evaluation relative to sensitivity, precision, accuracy, representativeness and completeness. These parameters have been presented in Section 1.4 of this attachment.

B-1.3 DATA VALIDATION

This project implemented the use of data validation checklists to facilitate laboratory data validation. These checklists were completed by the project designated validation staff and were reviewed by the project laboratory coordinator. Data validation checklists for each laboratory sample delivery group (SDG) have been retained with laboratory data deliverables by Science Application International Corporation (SAIC).

B-1.3.1 Laboratory Data Validation

Analytical data generated for this project have been subjected to a process of data verification, validation, and review. Several criteria have been established against which the data are compared and from which a judgment is rendered regarding the acceptance and qualification of the data. Because it is beyond the scope of this report to cite those criteria, the reader is directed to the following documents for specific detail:

- *USACE Kansas City and St. Louis District Radionuclide Data Quality Evaluation Guidance for Alpha and Gamma Spectroscopy, December 17, 2002b.*
- SAIC Technical Support Contractor QA Technical Procedure (TP-DM-300-7) *Data Verification and Validation.*

Upon receipt of field and analytical data, verification staff performed a systematic examination of the reports, following standardized data package checklists, to assess the content, presentation, and administrative validity of the data. In conjunction with data package verification, laboratory electronic data diskettes were available. These diskette deliverables were subjected to review and verification against the hardcopy deliverable. Both a structural and technical assessment of the laboratory-delivered electronic reports were performed. The structural evaluation verified that required data had been reported and contract specified requirements were met (i.e., analytical holding times, contractual turnaround times, etc.).

During the validation phase of the review and evaluation process, data were subjected to a systematic technical review by examining the field results, analytical QC results and laboratory documentation following appropriate guidelines for laboratory data validation. These data validation guidelines define the technical review criteria, methods for evaluation of the criteria, and actions to be taken resulting from the review of these criteria. The primary objective of this phase was to assess and summarize the quality and reliability of the data for the intended use and to document factors that may affect the usability of the data. Data verification/validation included but was not necessarily limited to the following parameters:

Method Requirements

Requirements for methods:

- Holding time information and methods requested
- Discussion of laboratory analysis, including any laboratory problems

Radiochemical Analysis

- Sample results
- Initial calibration
- Efficiency check
- Background determinations
- Spike recovery results
- Internal standard results (tracers or carriers)
- Duplicate results
- Self-absorption factor (α,β)
- Cross-talk factor (α,β)
- Laboratory control samples (LCS)
- Run log

As an end result of this phase of the review, the data were qualified based on the technical assessment of the validation criteria. Qualifiers were applied to each analytical result to indicate the usability of the data for its intended purpose.

B-1.3.2 Definition of Data Qualifiers (Flags)

During the data validation process, all laboratory data were assigned appropriate data validation flags and reason codes. Validation flags are defined as follows:

"=" Positive Result.

"U" When the material was analyzed for, but not detected above the level of the associated value.

"J" When the associated value is an estimated quantity. Indicating there is cause to question accuracy or precision of the reported value.

"UJ" When the analyte was analyzed for, but not detected, above the associated value, however, the reported value is an estimate and demonstrates a decreased knowledge of its accuracy or precision.

"R" When the analyte value reported is unusable. The integrity of the analyte's identification, accuracy, precision, or sensitivity has raised significant question as to the reality of the information presented.

SAIC validation flagging codes and copies of validation checklists and qualified data forms are on-file with the analytical laboratory deliverable.

B-1.4 DATA EVALUATION

B-1.4.1 Accuracy

Accuracy provides a gauge or measure of the agreement between an observed result and the true valuc for an analysis. Analytical accuracy is evaluated by measuring the agreement between an analytical result and its known or true value. This is generally determined through use of LCSs, matrix spike (MS) analysis, and performance evaluation (PE) samples. Accuracy, as measured through the use of LCSs, determines the methods implementation of accuracy independent of

sample matrix, as well as document laboratory analytical process control. Accuracy determined by the MS is a function of both matrix and analytical process.

B-1.4.1.1 Radiological Parameters

Individual sample chemical yields and LCS recoveries were within the ± 25% criteria for the verification samples, as stated in the SAG. Therefore, the data can be used for its intended purpose.

B-1.4.1.2 Inter-Laboratory Accuracy

As a measure of analytical accuracy, the relative percent difference (RPD) for split sample pairs for the two radiological analytical groups (i.e., alpha spectroscopy and gamma spectroscopy) were employed, using an independent contract laboratory. Sample homogeneity, analytical method performance, and the quantity of analyte being measured contribute to this measure of sample analytical accuracy.

As the RPD approaches zero, complete agreement is achieved between the split sample pairs. When one or both sample values were between the quantitation level and less than five times the analyte reporting level, the normalized absolute difference (NAD) was evaluated. If both samples were not detected for a given analyte, precision was considered acceptable.

The analytical accuracy (i.e., split precision) between the FUSRAP laboratory and the contract laboratory met the FSS goal of ensuring that 90 percent of the verification samples were within either the ±30% criteria for the RPD DQI or less than 1.96 for the NAD DQI (Table B-1 and Table B-2). All of the nine split sample pairs are within the criteria. Analytical results can be found in Table B-5 and Table B-6.

$$RPD = (S - D) / [(S + D) / 2] * 100\%$$

Where: S = Parent Sample Result

D = Field Split Result

$$NAD = (S - D) / [(U_S)^2 + (U_D)^2]^{1/2}$$

Where: S = Parent Sample Result

D = Field Split Result

U_S = Parent Sample Uncertainty

U_D = Field Split Uncertainty

Table B-1. Split Precision Among Alpha Spectroscopy Analyses

Sample Name	Thorium-228		Thorium-230		Thorium-232	
	RPD	NAD	RPD	NAD	RPD	NAD
SLD81680/SLD81680-2	N/A	0.76	NC	NC	NC	NC
SLD81702/SLD81702-2	N/A	0.24	NC	NC	NC	NC
SLD84112/SLD84112-2	*	*	*	*	*	*
SLD84118/SLD84118-2	N/A	0.06	NC	NC	NC	NC
SLD84124/SLD84124-2	N/A	0.42	NC	NC	NC	NC
SLD84138/SLD84138-2	N/A	0.14	NC	NC	NC	NC
SLD84272/SLD84272-2	N/A	0.20	NC	NC	NC	NC
SLD85142/SLD85142-2	NC	NC	NC	NC	NC	NC
SLD92880/SLD92880-2	N/A	0.20	NC	NC	NC	NC

NC – Value not calculated due to one or both of the results were non-detected.
N/A – Not applicable.
* – Analysis not conducted.

Table B-2. Split Precision Among Gamma Spectroscopy Analyses

	Actinium-227		Americium-241		Cesium-137		Potassium-40		Protactinium-231		Radium-226		Radium-228		Uranium-235		Uranium-238	
SampleName	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
SLD81680/SLD81680-2	NC	NC	NC	NC	NC	NC	11.6%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD81702/SLD81702-2	NC	NC	NC	NC	NC	NC	29.8%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD84112/SLD84112-2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SLD84118/SLD84118-2	NC	NC	NC	NC	NC	NC	N/A	0.95	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD84124/SLD84124-2	NC	NC	NC	NC	NC	NC	N/A	0.67	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD84138/SLD84138-2	NC	NC	NC	NC	NC	NC	28.6%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD84272/SLD84272-2	NC	NC	NC	NC	NC	NC	12.2%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD85142/SLD85142-2	NC	NC	NC	NC	NC	NC	N/A	0.13	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD92880/SLD92880-2	NC	NC	NC	NC	NC	NC	4.9%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC – Value not calculated due to one or both of the results were non-detected.
N/A – Not applicable.
* – Analysis not conducted.

B-1.4.2 Precision

B-1.4.2.1 Laboratory Precision

To evaluate precision within the on-site laboratory, lab duplicate samples were employed at a frequency of one duplicate per sample batch (no more than one duplicate per thirteen samples). As a measure of analytical precision, the RPD for laboratory duplicate sample pairs for the two radiological analytical groups (i.e., alpha spectroscopy and gamma spectroscopy) were employed at the time of verification and validation.

RPD and/or NAD values for all analytes were within the ±30% window of acceptance for the verification samples. Data tables are not provided in this summary report, as the data is inspected and results are documented in the sample delivery group packages at the time of verification.

B-1.4.2.2 Field Precision

Field duplicate samples were collected to ascertain the contribution to variability (i.e., precision) due to the combination of environmental media, sampling consistency, and analytical precision. The field duplicates were collected from the same spatial and temporal conditions as the primary environmental sample. Soil samples were collected from the same sampling device, after homogenization for all analytes.

For the nine field duplicate samples taken for the verification activities, the NAD and RPD values indicated acceptable precision for the data. All of the sample pairs were within acceptance criteria, as demonstrated in Tables B-3 and B-4. Analytical results can be found in Tables B-5 and B-6.

Table B-3. Field Duplicate Precision Among Alpha Spectroscopy Analyses

SampleName	Thorium-228		Thorium-230		Thorium-232	
	RPD	NAD	RPD	NAD	RPD	NAD
SLD81680/SLD81680-1	N/A	0.53	NC	NC	NC	NC
SLD81702/SLD81702-1	N/A	0.67	NC	NC	NC	NC
SLD84112/SLD84112-1	N/A	0.36	NC	NC	NC	NC
SLD84118/SLD84118-1	N/A	0.12	NC	NC	NC	NC
SLD84124/SLD84124-1	NC	NC	NC	NC	NC	NC
SLD84138/SLD84138-1	N/A	0.44	NC	NC	NC	NC
SLD84272/SLD84272-1	N/A	1.04	NC	NC	NC	NC
SLD85142/SLD85142-1	N/A	0.63	NC	NC	NC	NC
SLD92880/SLD92880-1	N/A	0.67	NC	NC	NC	NC

NC – Value not calculated due to one or both of the results were non-detected.
N/A – Not applicable.

B-1.4.3 Sensitivity

Determination of minimum detectable values allows the investigation to assess the relative confidence, which can be placed in a value in comparison to the magnitude or level of analyte concentration observed. The closer a measured value comes to the minimum detectable concentration, the less confidence and more variation the measurement will have. Project sensitivity goals were expressed as quantitation level goals in the FSSP (USACE 2002a). These levels were achieved or exceeded throughout the analytical process.

Table B-4. Field Duplicate Precision Among Gamma Spectroscopy Analyses

	Actinium-227		Americium-241		Cesium-137		Potassium-40		Protactinium-231		Radium-226		Radium-228		Uranium-235		Uranium-238	
SampleName	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
SLD81680/SLD81680-1	NC	NC	NC	NC	NC	NC	7.9%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD81702/SLD81702-1	NC	NC	NC	NC	NC	NC	0.1%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD84112/SLD84112-1	NC	NC	NC	NC	NC	NC	16.1%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD84118/SLD84118-1	NC	NC	NC	NC	NC	NC	13.4%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD84124/SLD84124-1	NC	NC	NC	NC	NC	NC	13.3%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD84138/SLD84138-1	NC	NC	NC	NC	NC	NC	7.1%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD84272/SLD84272-1	NC	NC	NC	NC	N/A	0.11	7.4%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD85142/SLD85142-1	NC	NC	NC	NC	NC	NC	10.5%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD92880/SLD92880-1	NC	NC	NC	NC	N/A	0.23	17.9%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC – Value not calculated due to one or both of the results were non-detected.
N/A – Not applicable.

B-1.4.4 Representativeness and Comparability

Representativeness expresses the degree to which data accurately reflect the analyte or parameter of interest for an environmental site and is the qualitative term most concerned with the proper design of a sampling program. Factors that affect the representativeness of analytical data include proper preservation, holding times, use of standard sampling and analytical methods, and determination of matrix or analyte interferences. Sample preservation, analytical methodologies, and soil sampling methodologies were documented to be adequate and consistently applied.

Comparability, like representativeness, is a qualitative term relative to a project data set as an individual. These investigations employed appropriate sampling methodologies, site surveillance, use of standard sampling devices, uniform training, documentation of sampling, standard analytical protocols/procedures, QC checks with standard control limits, and universally accepted data reporting units to ensure comparability to other data sets. Through the proper implementation and documentation of these standard practices, the project has established the confidence that the data will be comparable to other project and programmatic information.

Table B-6 compares sample results from the Field Duplicate and Split Samples to the associated Parent Sample. Results from the Split Sample are corrected in this table by a factor of 1.5 for comparability to the Parent Sample and Field Duplicate. This correction factor represents the ingrowth necessary to conservatively report Ra-226, as reported by the St. Louis FUSRAP Radiological Laboratory.

B-1.4.5 Completeness

Usable data are defined as those data, which pass individual scrutiny during the verification and validation process and are accepted for unrestricted use. The data quality objective of achieving 90% completeness, as defined in the FSSP was satisfied with the project producing valid results for 100 % of the sample analyses performed.

A total of one hundred fifity-four (154) systematic verification and forty-six (46) biased soil samples were collected with approximately 3,200 discrete analyses (i.e., analytes) being obtained, reviewed, and integrated into the assessment. The project produced acceptable results for 100% of the sample analyses performed.

B-1.5 DATA QUALITY ASSESSMENT SUMMARY

The overall quality of the VPs and Mallinckrodt West data meets or exceeds the established project objectives. Through proper implementation of the project data verification, validation, and assessment process, project information has been determined to be acceptable for use.

Data, as presented, have been qualified as usable, but estimated when necessary. Data that have been estimated have concentrations/activities that are below the quantitation limit or are indicative of accuracy, precision, or sensitivity being less than desired but adequate for interpretation.

Data produced for this characterization demonstrates that it can withstand scientific scrutiny, is appropriate for its intended purpose, is technically defensible, and is of known and acceptable sensitivity, precision, and accuracy. Data integrity has been documented through proper implementation of QA and QC measures. The environmental information presented has an established confidence, which allows utilization for the project objectives and provides data for future needs.

Table B-5. Alpha Spec Results for Parent Samples and the Associated Field Duplicates and Field Splits

Sample Name	Thorium-228	Thorium-230	Thorium-232
SLD81680	1.24	2.73	0.86
SLD81680-1	0.87	1.57	1.00
SLD81680-2	0.82	1.28	1.02
SLD81702	0.85	2.24	0.67
SLD81702-1	1.35	1.60	0.89
SLD81702-2	0.74	0.96	0.63
SLD84112	0.43	0.89	0.10
SLD84112-1	0.29	0.96	0.08
SLD84112-2	*	*	*
SLD84118	0.26	1.11	0.16
SLD84118-1	0.22	0.88	0.34
SLD84118-2	0.28	1.01	0.22
SLD84124	0.49	1.18	0.28
SLD84124-1	0.34	1.08	0.07
SLD84124-2	0.33	1.81	0.35
SLD84138	0.64	2.12	0.68
SLD84138-1	0.90	2.33	0.92
SLD84138-2	0.70	2.34	0.88
SLD84272	0.54	1.90	0.39
SLD84272-1	1.24	2.59	0.83
SLD84272-2	0.62	2.04	0.57
SLD85142	0.15	1.06	0.04
SLD85142-1	0.35	1.20	0.07
SLD85142-2	0.07	1.18	0.15
SLD92880	0.89	1.60	0.52
SLD92880-1	0.53	1.87	0.38
SLD92880-2	0.79	1.94	0.81

* -- Analysis not conducted.

Table B-6. Gamma Spec Results for Parent Samples and the Associated Field Duplicates and Field Splits

Sample Name	Actinium-227	Americium-241	Cesium-137	Potassium-40	Protactinium-231	Radium-226	Radium-228	Uranium-235	Uranium-238
SLD81680	0.05	0.04	0.00	15.61	-0.18	1.35	0.74	-0.01	1.35
SLD81680-1	-0.03	0.04	-0.01	14.43	-0.07	1.27	0.75	0.09	1.48
SLD81680-2	0.13	0.04	0.00	13.90	-0.62	1.545 [a]	0.69	0.07	0.05
SLD81702	-0.07	0.00	0.01	14.04	0.23	1.29	0.66	-0.12	1.11
SLD81702-1	0.11	0.02	0.00	14.03	0.20	1.35	0.70	-0.02	1.32
SLD81702-2	0.00	-0.09	0.02	10.40	-0.20	1.215 [a]	0.47	0.08	0.65
SLD84112	0.04	-0.02	0.02	5.84	-0.03	0.90	0.18	0.02	0.70
SLD84112-1	-0.06	-0.01	0.02	4.97	0.05	0.84	0.17	-0.04	0.66
SLD84112-2	*	*	*	*	*	*	*	*	*
SLD84118	0.08	0.01	0.00	2.86	-0.31	1.03	0.16	0.04	0.72
SLD84118-1	0.05	0.03	0.02	3.27	-0.02	1.15	0.17	0.04	0.68
SLD84118-2	0.08	0.01	-0.02	1.98	0.52	1.05 [a]	0.14	-0.17	0.65
SLD84124	0.00	0.00	0.02	2.04	0.01	1.27	0.19	0.07	0.95
SLD84124-1	-0.08	0.02	0.02	2.33	0.16	1.20	0.17	0.11	0.91
SLD84124-2	0.05	0.00	0.01	2.80	-0.45	1.935 [a]	0.15	-0.24	0.77
SLD84138	0.12	0.07	-0.03	11.60	0.65	2.67	0.95	0.69	2.46
SLD84138-1	-0.22	0.02	0.02	10.80	-0.66	2.70	0.90	0.30	2.33
SLD84138-2	0.16	-0.03	0.02	8.70	1.70	2.535 [a]	0.71	-0.14	2.20
SLD84272	0.08	0.03	0.10	5.84	0.05	2.26	0.49	0.15	1.89
SLD84272-1	-0.01	0.07	0.10	6.29	0.29	1.91	0.49	0.06	1.82
SLD84272-2	0.07	-0.02	0.06	6.60	-0.10	2.415 [a]	0.42	-0.10	0.83
SLD85142	0.01	0.02	0.00	1.61	0.14	1.05	0.07	0.02	0.69
SLD85142-1	0.01	0.00	0.00	1.45	-0.07	1.06	0.07	0.00	0.63
SLD85142-2	0.08	-0.03	-0.01	1.71	-0.37	1.23 [a]	0.13	-0.09	0.69
SLD92880	0.18	0.02	0.07	9.24	-0.27	1.47	0.59	0.08	2.19
SLD92880-1	0.06	0.02	0.08	7.72	-0.12	1.40	0.51	0.00	1.68
SLD92880-2	0.03	-0.01	0.07	8.80	0.50	2.94 [a]	0.36	0.16	2.60

* -- Analysis not conducted.
[a] – Value corrected by a factor of 1.5 for comparability.

ATTACHMENT C

ALARA ANALYSIS

ALARA ANALYSIS

The 10 CFR 20 Subpart E ARAR pertains to the extent to which lands must be remediated before decommissioning of a site can be considered complete and the license terminated. The standards are for unrestricted use, 25 mrem/yr, TEDE, ALARA and for unrestricted use, 25mrem/yr TEDE, 100 mrem/yr with loss of controls, and ALARA. Soils containing small areas of elevated activity (i.e. having a SOR value >1) that meet the RG may be left in place. Areas of elevated activity meet the RGs by demonstrating that the 40 CFR 192 ARAR is met and by showing that residual risks for the properties do not exceed the CERCLA target risk range.

An ALARA evaluation was performed consistent with NUREG-1727 (NCR 2000) as a measure of the cost effectiveness of leaving small elevated areas of soils in place verses the benefit of remediation. Soil samples with a SOR value in excess of 1.0 are listed in Tables 2 and 3 of this report.

NUREG-1727 gives the formula for calculating the benefit from averted dose (AD) as provided below.

$$B_{AD} = \$2{,}000 \times PW(AD_{collective})$$

Where:

B_{AD}	=	benefit from averted dose for a RA
\$2,000	=	value in dollars of a person-rem averted
$PW(AD_{collective})$	=	present worth of future collective averted dose.

The present worth of the future averted collective dose can be calculated from the equation shown below.

$$PW(AD_{collective}) = P_D \times A \times 0.025 \times F \times \frac{Conc}{DCGL_W} \times \frac{1 - e^{-(r+\lambda)N}}{r + \lambda}$$

Where:

P_D	=	population density for the critical group scenario in people/m^2, 0.0004.
A	=	area being evaluated in m^2, 27 m^2 is used as the sum of the areas exceeding a SOR value of 1 (see Attachment 4-1)
0.025	=	annual dose to an average member of the critical group from residual radioactivity at the concentration-based RG in rem/yr.
F	=	fraction of the residual activity removed by the RA; in this case F = 1 to represent areas exceeding a SOR value of 1.
Conc	=	average concentration of residual radioactivity in the area being evaluated. The area weighted SOR_N for the elevated accessible soil areas of West of Broadway VPs and Mallinckrodt West is 1.7 (see Attachment D-1)
$DCGL_W$	=	derived concentration guideline limit; in this case, $SOR_N = 1$.
r	=	monetary discount rate; 0.03/yr as recommended by NUREG-1727.
λ	=	radiological decay constant. U-238 was chosen as the representative decay constant because this would give the most conservative result (highest present worth factor) = 1.55 E-10/yr.
N	=	number of years over which the collective dose will be calculated; 1000 as recommended by NUREG-1727.

Although the SOR value of 1 that was used as the concentration-based RG for West of Broadway VPs and West Mallinckrodt is not based on the 25 mrem, using 0.025 rem/yr (i.e., 25 mrem/yr) in the equation is a conservative approach because the calculated doses from the elevated areas

are all less than 25 mrem/yr. Using these equations, the benefit from the averted dose (B_{AD}) was calculated to be approximately $30.60.

The cost of remediating the remaining areas was based on the average cost incurred by remediation contractors during similar projects in the St. Louis District, but does not include overhead, mobilization, and other related costs that NUREG-1727 allows to be considered in an ALARA analysis. The estimated cost of excavation, transportation, and disposal of the remaining elevated areas is approximately $4726. This cost assumes that a surface area of 27 m^2 would be excavated to a depth of 1 foot below ground surface at a unit cost of $439/cubic yard. The cost of further remediation greatly exceeds the economic benefit of the averted dose, therefore the action is considered ALARA.

ATTACHMENT D

EVALUATION OF 100 m^2 REMEDIATION GOAL

Table D-1. Evaluation of 100 m^2 Aerial Average Remediation Goal

Mallinckrodt Property	Survey Unit	Sample Number	SOR_N	Effective Surface Area (m^2)	Area Weighted Average SOR
Plant 3	SU-1	**HTZ66329**	**3.45**	3.0	0.51
		HTR84770	**1.11**	2.0	
		HTR84771	0.31	3.0	
		HTR84772	**2.34**	2.0	
		HTR84773	0.50	15.0	
		SLD84696	0.47	15.0	
		SLD84700	0.95	4.0	
		HTR84767	0.28	20.0	
		HTR84768	**2.51**	3.0	
		HTR84769	0.33	3.0	
		SLD84111	0.00	30.0	
Plant 3	SU-1	**HTR84775**	**1.23**	17.0	0.37
		HTR87774	0.02	16.0	
		HTR84778	0.07	17.0	
		SLD84130	0.29	50.0	

The area weighted average for samples with $SOR_N > 1 = 1.7$

Bold font indicates $SOR_N > 1$

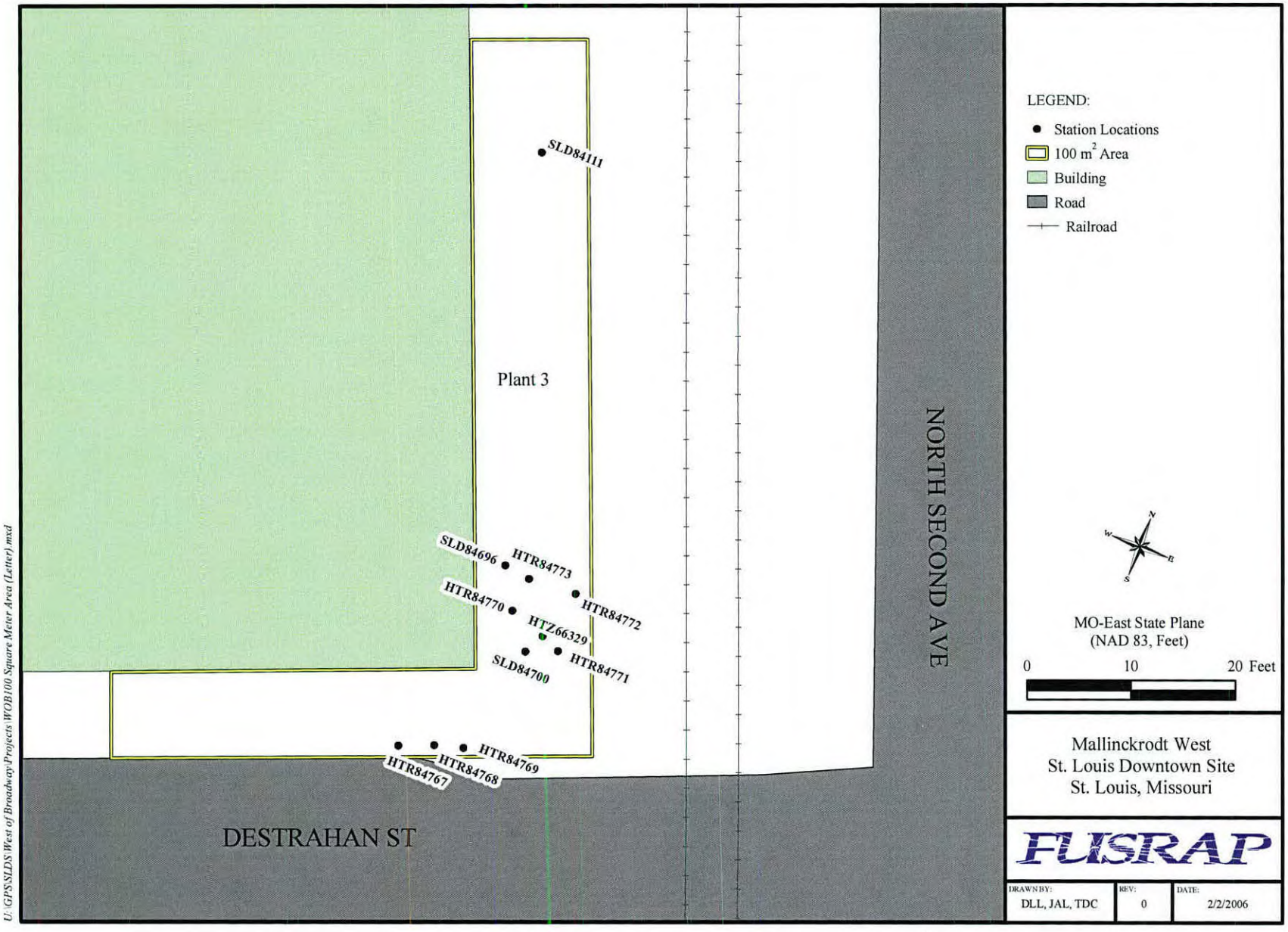

Figure D-1. West of Broadway and Mallinckrodt West Properties 100 m^2 Area

AR-110