REVISION 0

PRE-DESIGN INVESTIGATION AND FINAL STATUS SURVEY EVALUATION FOR THE ACCESSIBLE SOILS WITHIN THE ST. LOUIS DOWNTOWN SITE VICINITY PROPERTIES DT-35 AND DT-36

ST. LOUIS, MISSOURI

MAY 7, 2009

U.S. Army Corps of Engineers
St. Louis District Office
Formerly Utilized Sites Remedial Action Program

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ACRONYMS AND ABBREVIATIONS

Common unit abbreviations are not defined in this list. Both English and metric units are used in this report. The units used in a specific situation are based on common unit usage or regulatory language. For example, depths are given in feet (common usage) and areas are given in square meters (regulatory usage).

Δ/σ_{eff}	relative shift
σ_{eff}	effective standard deviation
Ac	actinium
AEC	U.S. Atomic Energy Commission
Am	americium
ARAR	applicable or relevant and appropriate requirement
bcm	below cover material
bgs	below ground surface
BNI	Bechtel National, Inc.
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	Code of Federal Regulations
COC	contaminant of concern
cpm	counts per minute
C_{RA}	concentration of the representative area
Cs	cesium
DCGL	Derived Concentration Guideline Level
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FS	feasibility study
FSS	final status survey
FSSE	final status survey evaluation
FSSP	final status survey plan
FUSRAP	Formerly Utilized Sites Remedial Action Program
GWS	gamma walkover survey
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 (U.S. Army Corps of Engineers)
mrem/yr	millirem per year
NAD	normalized absolute difference
N/A	not applicable
NC	value not calculated
NRC	U.S. Nuclear Regulatory Commission
OU	operable unit

ACRONYMS AND ABBREVIATIONS (Continued)

Pa	protactinium
Pb	lead
pCi/g	picocuries per gram
PDI	pre-design investigation
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QCSR	Quality Control Summary Report
QSM	DoD *Quality Systems Manual for Environmental Laboratories*
Ra	radium
RAO	remedial action objectives
RESRAD	Residual Radioactivity
RG	remediation goal
RPD	relative percent difference
SAG	*Sampling and Analysis Guide for the St. Louis Sites*
SAIC	Science Applications International Corporation
SLDS ROD	*Record of Decision for the St. Louis Downtown Site*
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
USACE	U.S. Army Corps of Engineers
VQ	validation qualifier
WRS	Wilcoxon Rank Sum

ABSTRACT

Site Name and Operable Unit	St. Louis Downtown Site Vicinity Properties: Community Wholesale Tire (formerly Factory Tire Outlet) (DT-35) and OJM, Inc. (DT-36).
Location	St. Louis, Missouri.
Regulatory Oversight	U.S. Environmental Protection Agency (EPA), Region 7. Missouri Department of Natural Resources.
Contractor Oversight	U.S. Army Corps of Engineers, St. Louis District.
Verification Contractor	Science Applications International Corporation (SAIC).
Waste Source	Uranium ore processing and uranium metal production in the 1940s and 1950s.
Contaminants	Radionuclides from the uranium-238, thorium-232, and uranium-235 decay series.
Remediation Method, Quantity, and Date	Accessible Soil: None required.
Regulatory Requirements/ Remediation Goals	See Section 2.1.3 for Record of Decision requirements.
Results	**The accessible soil on DT-35 and DT-36 is releasable for unrestricted use based on the soil sampling results, radiological surveys, and a risk and dose assessment**. The highest residual risk calculated for these properties is 7×10^{-5}, which met the target risk[1] range 10^{-6} to 10^{-4}. This potential risk was the highest result for the next 1,000 years, was based on a residential scenario, and assumed no cover materials over the residual soil.
Remediation Cost	When all of the projects within the program have been completed, the programmatic costs will be presented in a final closeout report.
Description	From 1942 until 1957 Mallinckrodt Chemical Works was contracted by the Manhattan Engineer District and the Atomic Energy Commission to process various feed materials for the production of uranium metal. Materials from uranium processing were inadvertently released into the environment.

[1] When estimating cancer risk, a lifetime risk level for an exposed individual and how many additional cancer cases might occur in a population of exposed people (i.e., 1×10^{-6} is equal to one additional case in a population of a million) are predicted. These are cancers that may or may not occur, but if they were to occur, they would be in addition to cancers from other causes, such as smoking tobacco. For non-cancer toxicity, a daily exposure level that is likely to be of little risk to people is estimated.

1.0 INTRODUCTION

The *Record of Decision (ROD) for the St. Louis Downtown Sites* (USACE 1998a) provides the final remedial action for the accessible soil and ground water contaminated as the result of Manhattan Engineer District (MED) and U.S. Atomic Energy Commission (AEC) uranium manufacturing and processing activities at the St. Louis Downtown Site (SLDS).

The work that is the subject of this report was performed under the Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was initiated by the AEC in 1974 to identify, remediate, or otherwise control sites where residual radioactivity remains from operations conducted for MED and AEC during the early years of the nation's atomic energy program (USACE 1998a). FUSRAP was continued by the follow-on agencies to the AEC until 1997 when the U.S. Congress transferred responsibility for the execution aspect of FUSRAP from the U.S. Department of Energy (DOE) to the U.S. Army Corps of Engineers (USACE). The DOE will assume a stewardship responsibility beginning two years after completion of the RA at the SLDS.

The USACE was authorized by Congress as the lead agency for implementation of the Selected Remedy. The remedy was jointly selected by the USACE and the U.S. Environmental Protection Agency (EPA) with the concurrence of the Missouri Department of Natural Resources (MDNR). The work within the scope of the report was managed by the USACE St. Louis District FUSRAP Project Office. This work was accomplished in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA).

This report specifically documents the Pre-Design Investigation (PDI) and Final Status Survey Evaluation (FSSE) conducted at the properties described in Section 1.1. The PDI was conducted at these properties because they were potentially impacted by the inadvertent release of materials from uranium processing at the Mallinckrodt Chemical Works (Mallinckrodt).

When it was determined that no remedial action would be necessary at these properties, an FSSE was conducted using *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (Department of Defense [DoD] 2000) procedures to ensure that any residual radioactivity does not exceed the criteria specified in the *Record of Decision for the St. Louis Downtown Site* (SLDS ROD) (USACE 1998a). The information presented in this report demonstrates that each of these properties is in compliance with the SLDS ROD.

1.1 PROPERTY DESCRIPTIONS

This report addresses two properties in downtown St. Louis that are owned by Community Wholesale Tire (DT-35) and OJM, Inc. (DT-36). The properties are located near the intersection of the Bremen Street and Broadway. Table 1 contains the addresses of the properties being addressed and the parcel designations established by the City of St. Louis (STLCity 2008). In addition, Table 1 lists the designations given to these properties for this specific project. Table 1 also identifies whether the road right-of-way (ROW) along each property is addressed as part of the property for the purposes of this report. The locations of these properties are identified in Figure 1 using the "DT" designations. These properties are being addressed in this report because they were potentially impacted by the inadvertent release of residual radioactivity from uranium metal production processes. If present, radiological contamination at these properties would be due to contaminant migration caused by airborne deposition and possible waterborne transport from Mallinckrodt property located to the southeast of DT-35 and DT-36, or due to transportation of radiological materials along Broadway or the railroad corridor on the east side of DT-35.

Table 1. Addresses, Parcels, and Designations

Address	Parcel	Designation for this Project	Right-of-Way Included
3732 N Broadway	25290000300	DT-35	No
3800-3806 N Broadway	19320000100	DT-35	No
3812 N Broadway	19320000200	DT-35	No
200 Bremen Avenue	19320000300	DT-35	No
3743 N Broadway	12170001051	DT-36	No
3801-3803 N Broadway	19310000600	DT-36	No
800-830 Bremen Avenue	19310000501	DT-36	No
3800-3810 N 9th Street	19310000108	DT-36	No

DT-35 and DT-36 were not specifically identified as part of the SLDS in the SLDS ROD. However, the SLDS boundaries were later clarified to include these and other properties in accordance with the *Memorandum: Non-Significant Change to the Record of Decision for the St. Louis Downtown Site* (USACE 2005c).

DT-35 is bordered to the west by Broadway, to the north by Bremen Street, to the south by DT-11, and to the east by Norfolk Southern railroad tracks and Second Street. DT-35 consists of four buildings that cover the majority of the property. The rest of the property is covered by asphalt, concrete, with small areas of soil and gravel. A review of aerial photographs (USACE 1941-1995) indicates that the two large buildings were constructed prior to 1941. The two smaller buildings on the northeast side of the property appear to have been built between 1988 and 1989, based on review of these same photographs.

DT-36 is bordered to the west by DT-11, a private property, and Ninth Street; to the north by the former location of Bremen Street; to the south by DT-11; and to the east by Broadway. DT-36 consists of one large building; the remainder of the property is covered by asphalt, concrete or gravel. Aerial photographs (USACE 1941-1995) show several small buildings that appear to have been all connected after 1974 to form one large building.

1.2 GEOPHYSICAL FEATURES

The regional geological setting of the subsurface soils at the SLDS is generally characterized by a fill layer which extends from the surface down to a layer of alluvial sediments (i.e., silty sediments deposited by flowing water). The alluvial sediments overlay the bedrock. The fill, discernable as multiple horizons at most locations, has an average thickness of 13 feet and may contain concrete, brick, glass, coal cinders, slag material, and/or other miscellaneous material that was placed on top of the original flood plain sediments in the late 1800s and early 1900s. The alluvial flood plain deposits underlying the fill material consist of stratified clays, silts, sands, and gravels that range in thickness from 5 to 30 feet. The alluvial deposits generally become coarser grained with depth. Earthquake faults are not evident.

Under the fill and alluvial deposits, the uppermost bedrock unit underlying the SLDS is the Mississippian age Ste. Genevieve Formation. The formation is composed of limestone with some dolomite. The depth to bedrock at the SLDS ranges from approximately 10 ft below ground surface (bgs) on the western side of the property to 80 ft bgs near the Mississippi River.

The current topographic ground surface of DT-35 and DT-36 is covered with consolidated cover material such as concrete and/or asphalt and unconsolidated cover material such as gravel. Buildings and consolidated cover materials cover over 95 percent of the surface area of both properties.

The shallow sampling performed in conjunction with the PDI at DT-35 and DT-36 confirmed the presence of a fill layer at both sites. This fill material was encountered from the ground surface (or below the paved surface) to the bottom of each boring. The maximum depth of the PDI borings was 6 ft bgs. The fill materials consisted primarily of gravel, sand, clay, and cinders. To a lesser extent, the fill matrix also included broken pieces of brick, glass, and slag. Stratification of these fill materials was not observed during the sampling efforts. Additional information on the fill materials encountered in the shallow borings is provided on the Field Logbook entries for samples on the CDROM attached to the back cover of this report.

Surface water run off for DT-35 and DT-36 follows the surface topography, which slopes gently from west to east towards the Mississippi River. The surface water run off is collected in various inlets to the St. Louis Municipal storm water underground drainage system which conveys the water to the Mississippi River. The Mississippi River flooded in July 1947 (USACE 1941-1995) and areas adjacent to DT-35 and DT-36 were flooded, but DT-35 and DT-36 were not. The area is now protected by a flood control levee.

1.3 GROUND WATER

Ground water at the SLDS is found within three horizons (or hydrostratigraphic units): the upper, nonlithified (soil) unit, referred to as the "A Unit;" the lower, nonlithified unit, referred to as either the Mississippi Alluvial Aquifer or the "B Unit;" and the bedrock (the lithified water-bearing unit), referred to as the "C unit". The Mississippi Alluvial Aquifer is the principal aquifer in the St. Louis area, including the SLDS area. Aquifers in this region also exist in the bedrock formations underlying the alluvial deposits.

The upper ground-water unit at the SLDS (the A Unit) consists of fill overlying naturally deposited clays and silts. This shallow unit is not a potential source of drinking water due to poor yield and poor quality (i.e., chemical pollutants from the surrounding highly industrialized area). The A Unit is underlain by the sandy silts and silty sands of the Mississippi Alluvial Aquifer (the B Unit). Ground waters of the St. Louis area are generally of poor quality and do not meet drinking water standards without treatment. Expected future use of ground water at the SLDS is minimal, since the higher quality and large quantity of the Mississippi and Missouri Rivers is readily available. There are no water wells on DT-35 or DT-36.

1.4 NATURE AND EXTENT OF CONTAMINATION

From 1942-1957, Mallinckrodt processed uranium ore and other feed materials to produce various forms of uranium compounds and uranium metal for U.S. military purposes under contract to the Manhattan Engineer District (MED) and the AEC. Mallinckrodt performed this processing at its facilities in downtown St. Louis, Missouri. Materials from uranium processing were inadvertently released into the environment. The primary contaminants of concern (COCs) for these properties are the metals radium (Ra), thorium (Th), and uranium (U) and their decay products. Soil on various parts of Mallinckrodt property and some vicinity properties has been determined to have COCs above background levels. Vicinity properties may have been impacted by contaminant migration by air, water, transportation or a combination thereof.

1.5 ENVIRONMENTAL MONITORING

There are no ground-water monitoring wells on DT-35 or DT-36. Environmental monitoring for the FUSRAP project in St. Louis has confirmed that radiation safety regulations for the public, workers, and environment have been met during the conduct of the activities on DT-35 and DT-36. Each year, the monitoring data, and analysis of that data, have been documented in annual reports.

1.6 CURRENT AND REASONABLY ANTICIPATED FUTURE USE

The current land uses of DT-35 and DT-36 consist predominately of commercial/industrial and transportation-related uses. No significant changes in land use are anticipated. The likely future land use is commercial/industrial, based on a review of local development plans, discussions with local land use committees, and existing zoning restrictions within the area.

1.7 SUMMARY OF COMMUNITY INVOLVEMENT ACTIVITIES PERFORMED

The community has been provided with multiple opportunities to be involved with the decision process at the SLDS. In 1994 two committees were established for the purpose of working closely with FUSRAP representatives and serving as a "voice of the people." These organizations were the St. Louis Radioactive and Hazardous Waste Oversight Committee and the City of St. Louis Mayor's Advisory Task Force on Radioactive Waste. In 1994, the St. Louis Sites Remediation Task Force, made up of members from the above-referenced two groups plus other community stakeholders, was established. Working together as the St. Louis Sites Remediation Task Force, these organizations studied cleanup activities at the St. Louis Sites and, in 1996, issued a report detailing the community's recommendations for cleanup and removal of MED/AEC contaminants. Eventually, in 1997, the smaller St. Louis Oversight Committee was formed from members of these organizations. These organizations have developed strong working relationships with FUSRAP and have been active participants in the decision-making process. USACE provided quarterly briefings at the St. Louis Oversight Committee meetings, which were open to the public. The USACE maintains a web site with current information about the status of the St. Louis FUSRAP Sites and historical documentation. Newsletters and fact sheets were distributed throughout the community on an as-needed basis.

The FS and Proposed Plan for the SLDS were made available to the public in April 1998. A public meeting was advertised and held on April 21, 1998 to hear comments and answer questions regarding the SLDS FS and Proposed Plan. A 30-day comment period for the Proposed Plan for the SLDS began on April 8, 1998 and ended on May 8, 1998. Responses to the comments received from the public, and local, state and federal agencies are provided in the Responsiveness Summary included as Part 12 to the ROD.

A public meeting was held on April 21, 1998, to present the FS and Proposed Plan to interested members of the community. A notice announcing the availability of the SLDS FS and Proposed Plan and the intent to hold a public meeting to discuss the documents was published in the Federal Register and in the *St. Louis Post-Dispatch*. The meeting included an open-house session allowing one-on-one discussions with agency representatives, an informal presentation, and an open microphone question and answer period. The transcript of the public meeting and comment period was made available to the public on the USACE's St. Louis District FUSRAP website *http://www.mvs.usace.army.mil/eng-con/expertise/fusrap.html* and is included as part of the Administrative Record.

Program documents are made available to the public. They can be found in the Administrative Record maintained at the USACE FUSRAP Project Office, 8945 Latty Avenue, Berkeley, Missouri, or at the St. Louis Public Library, Government Information Section, 1302 Olive Street, St. Louis, Missouri. In addition, SLDS documents only are available for public access at the Henry Clay Elementary School, 3820 North 14th Street, St. Louis, Missouri.

2.0 BACKGROUND ON THE REMEDIATION PROCESS AND PRE-DESIGN INVESTIGATION

The purpose of the PDI activities was to summarize the existing data, define additional data needs, and determine if residual radiological contamination above the SLDS ROD remediation goals (RGs) was present on DT-35 and DT-36. The PDI was executed on DT-35 and DT-36 to collect additional data to be used in design or to confirm the property meets the RGs as presented in the ROD. This section describes the PDI conducted in 2006 and the associated conclusions. Although no remedial action was required at DT-35 and DT-36 this section also summarizes the remedial action objectives (RAOs), selected remedy, and RGs that are specified in the SLDS ROD.

2.1 REMEDIAL ACTION

The CERCLA Remedial Action process began with gathering existing information about the SLDS and determining if there was a threat to human health and the environment. In 1982, on behalf of the DOE, Bechtel National Inc. (BNI), the project management contractor for FUSRAP, began gathering this information. A remedial investigation was performed to characterize the extent and type of release, and to evaluate the risk to human health and the environment. The results of the investigation were documented in the *Remedial Investigation Report for the St. Louis Site* (DOE 1994). The *Feasibility Study for the St. Louis Downtown Site* (SLDS FS) (USACE 1998b) was developed to evaluate remedial alternatives. While DT-35 and DT-36 were not specifically addressed during the remedial investigation activities, the Mallinckrodt plants to the southeast were included and generated the types of potential radiological contamination that could be expected at the SLDS.

2.1.1 Remedial Action Objectives

RAOs were established early in the CERCLA process for the SLDS. The RAOs served as a basis for developing remedial action alternatives for the SLDS ROD. The RAOs describe what the remedial action needs to accomplish in order to be protective of human health and the environment. Table 2 identifies the following RAOs for the SLDS (USACE 1998a).

Table 2. SLDS Remedial Action Objectives

Medium	Remedial Action Objective
Accessible Soil	Prevent exposures from surface residual contamination in soils greater than the criteria prescribed in 40 Code of Federal Regulations (CFR) Part 192.
	Eliminate or minimize the potential for humans or biota to contact, ingest, or inhale soil containing COCs.
	Eliminate or minimize volume, toxicity, and mobility of impacted soil.
	Eliminate or minimize the potential for migration of radioactive materials offsite.
	Comply with Applicable or Relevant and Appropriate Requirements (ARARs).
	Eliminate or minimize potential exposure to external gamma radiation.
Ground water	Remove sources of COCs in the A Unit.
	Continue to maintain low concentrations of Operable Unit (OU) COCs in the B Unit.

2.1.2 Selected Remedy

The selected remedy for the SLDS was Alternative 6 from the SLDS FS, "Selective Excavation and Disposal". The selected remedy addresses accessible soil and ground water contaminated as a result of MED/AEC uranium ore processing activities. Contaminants from other sources that are commingled with the MED/AEC COCs would be addressed at the same time.

The main components of the selected remedy for the SLDS consist of:

- Excavation and off-site disposal of approximately 85,000 yd^3 of in-situ contaminated soil for all of the SLDS, and
- Perimeter monitoring of the ground water in the B Unit will be performed and the need for ground water remediation will be evaluated as part of the periodic reviews performed for the site. No remedial action is required for ground water beneath the site.

The following points were identified in the SLDS ROD in selecting this remedy.

- The current land use is generally commercial/industrial with some residences and a recreational bike trail adjacent to the Mississippi River. The closest residential dwelling is located approximately 200 ft southwest of the southwestern corner of the SLDS. Zoning regulations prohibit new residences from being established in the area. No significant changes in land use are expected (USACE 1998a).
- Groundwater is not currently used as a water-supply source. The contaminated shallow ground-water system is not considered to be a potential source of drinking water due to its poor quality and very low yields. The Mississippi Alluvial Aquifer (the B Unit) is considered to be a potential source of drinking water. However, its use for a drinking water resource is highly unlikely for several reasons, including the industrial setting of the SLDS, the site's proximity to both the Mississippi River and the city's drinking water supply, and its poor water quality (i.e., naturally-occurring high dissolved solids and metal content).
- Approved borrow obtained from an offsite location will be used to backfill excavations.
- The final status survey (FSS) will be compatible with the MARSSIM.

2.1.3 Remediation Goals

Achievement of RGs demonstrates that residual concentrations of COCs within accessible soil on the property is protective and can be released in accordance with the Selected Remedy. Table 3 lists the RGs, their applicability to DT-35 and DT-36, and the method for confirming that the applicable RGs have been achieved.

The media to be evaluated at DT-35 and DT-36 is limited to accessible soil. DT-35 and DT-36 do not have ground-water monitoring wells. Ground-water monitoring results associated with the SLDS are documented in annual environmental monitoring reports. There is no creek or other such surface water and sediment on these properties. There were no structures or consolidated materials that required investigation on these properties.

Inaccessible soils are not within the scope of the SLDS ROD or the FSSE. Inaccessible soils include the footprint of a building, the supporting soils beneath the footprint, and the soils adjacent to the building necessary for structural stability and safety of the building. Similarly, inaccessible soils may be associated with other structures, such as roadways, rail lines, and flood control levees.

collectively referred to as "ARARs," unless such ARARs are waived under CERCLA section 121(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those State standards that are identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable.

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those State standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate.

The key ARARs, as presented in the SLDS ROD, are listed below.

40 CFR Part 192, Section 192.12(a) is relevant and appropriate: The selected remedy will comply with the requirement that the "Residual radioactive material concentration of Ra-226 and Ra-228 in land averaged over any 100 m^2 area shall not exceed the background level by > 5 pCi/g averaged over the first 15 cm of soil (6 inches) and 15 pCi/g averaged over 15 cm thick layers of soil > 15 cm below the surface."

40 CFR Part 192, Subpart B, Section 192.02(b)(1) is relevant and appropriate: Radon-222 releases will not exceed an average rate of 20 pCi/m^3/s or increase the average annual concentration by more than 0.5 pCi/L in air outside the site.

40 CFR Part 192, Sections 192.40 and 192.41 are relevant and appropriate: This regulation was used in developing the thorium cleanup criteria for sites where thorium ores were processed.

40 CFR Parts 257-272 are relevant and appropriate: The selected remedy will comply with 40 CFR Parts 257-272, which establish accountability in handling hazardous waste from generation to disposal.

10 CFR 20, Subpart E is applicable: This rule provides consistent standards to NRC licensees for determining the extent to which lands must be remediated before decommissioning of a site can be considered complete and the license terminated.

2.2 PRE-DESIGN INVESTIGATION INFORMATION

The purpose of the PDI is to summarize the historical data, to characterize the properties, and to determine if the area requires remediation or is ready for FSS.

2.2.1 Historical Information Review Results

Historical information is defined in this document as information that was gathered prior to the transfer of responsibility from the DOE to the USACE in October 1997. A review of the historical documents for DT-35 and DT-36 provided very limited information since these properties were not part of the historical MED/AEC operations and were not suspected as being contaminated by these activities. Review of historical records does not indicate that sampling for radiological contaminants was performed on DT-35 or DT-36 prior to 2006.

An evaluation of historical aerial photographs and other documentation (USACE 1945-1995) was performed to assess potential contaminant migration pathways affecting DT-35 and DT-36. This evaluation concentrated on the period during which uranium metal production took place at Mallinckrodt (1942 to the late 1950s) to the 1980s.

- Aerial photograph dated July 3, 1947: The Mississippi River is shown in this photograph in flood stage. The flood water extends from the Mississippi River west to North Second Street, but does not reach DT-35 or DT-36. The elevation of the flood water is approximately 420 ft above mean sea level. The elevations of DT-35 and DT-36 are higher than the flood water elevation. The road and railroad configuration in the vicinity of DT-35 are consistent with existing conditions. A large building exists at the south end of DT-35 in the location of a building currently located on the property. A rail line is located along Second Street to the east of DT-35. DT-36 is not visible on the aerial photograph.
- Acrial photograph dated March 28, 1952: DT-35 and the east half of DT-36 are shown in this photograph. The properties and the surrounding area are being used for commercial/ industrial purposes. The buildings, roads, and railroads are consistent with the current configuration with the following notable exceptions. The existing small buildings at the north end of DT-35 are not present in the photograph. Several small buildings are located on DT-36 in the location of the existing main building on this property. A rail spur is depicted entering the east side of DT-35, but is not currently present at the property.
- Aerial photograph dated May 5, 1955: DT-35 is shown in this photograph. No appreciable changes were noted at DT-35 when comparing the 1952 and 1955 aerial photographs.
- Aerial photograph dated 1962: DT-35 and DT-36 are shown in this photograph. The road and railroad configuration is consistent with the existing conditions, with the following exceptions. The aerial photograph depicts Farrar Street crossing DT-36. The rail spur noted in the 1952 aerial photograph remains at the site. There are no appreciable changes with regard to the buildings when comparing the 1955 and 1962 photographs.
- Aerial photograph dated March 5, 1968: DT-35 and DT-36 are shown in this photograph. The only appreciable change between the 1962 and 1968 photographs is the elimination of the rail spur entering the east side of DT-35.
- Aerial photograph dated July 30, 1974: DT-35 and DT-36 are shown in this photograph. The buildings at the south end of DT-36 have been reconfigured in this photograph. Some of the previously existing buildings have been removed and others have been expanded.
- Aerial photograph dated May 5, 1983: There are no appreciable changes to DT-35 and DT-36 in the 1974 and 1983 photographs.

Potential contaminant migration scenarios were identified through the review of historical documentation. The potential migration scenarios include:

- Airborne transport via dust from former processing operations and/or wind erosion from stockpiles.

- Direct loss of materials from hauling trucks and railcars. Given the configuration of roads and railroads and the proximity of these properties to the former Mallinckrodt processing operations, this migration scenario could not be ruled out.
- Transport via storm water causing erosion of residues from stockpiles or from the beds of trucks.
- Ponding from stormwater backup on the west side of the floodwall that occurred on the property due to the inability to remove the stormwater during a flooding event.

Transport of materials via flood water from the Mississippi River was considered as a potential migration scenario, but was ruled out because the highest flood water elevation in the SLDS area between 1941 and 1955 was determined to be 420 ft above mean sea level. This flood water elevation is less than the ground surface elevation of DT-35 and DT-36. After 1955, the SLDS was protected from flooding by the USACE constructed floodwall, further reducing the potential for flood water impacting DT-35 and DT-36.

These potential contaminant migration scenarios were investigated through the PDI and FSS processes.

2.2.2 Pre-Design Investigation Survey

The available data leading up to the PDI survey indicated that existing conditions could meet the RGs. Accordingly, the PDI survey was designed to meet MARSSIM in the event that the results could also serve as the FSS. MARSSIM states, "In some cases when no remediation is anticipated, results of the characterization survey may indicate compliance with derived concentration guideline levels (DCGLs) established by the regulatory agency. When planning for the potential use of characterization survey data as part of the final status survey, the characterization data must be of sufficient quality and quantity for that use." For the PDI on DT-35 and DT-36, the sample grid and random sample locations were developed in anticipation that the sample results could be used for the FSS. The sample results are presented in Appendix C. The FSS design and methodology is discussed in Sections 3.2.1 through 3.2.3.

2.3 CONCLUSIONS FROM EXISTING DATA

Historical and PDI information indicated that there was not residual radioactivity above the RGs on DT-35 and DT-36 and the properties were ready for an FSS. The PDI sample data was of sufficient quality and quantity to be used for the FSS. Additional surveying and sampling of DT-35 and DT-36 was not necessary to meet the requirements of the FSS.

3.0 FINAL STATUS SURVEY PROCESS

3.1 DATA QUALITY OBJECTIVES

The Data Quality Objective (DQO) process is a strategic planning approach for a data collection activity. It provides a systematic procedure for defining the criteria that a data collection design should satisfy, including where to collect samples, how many samples to collect, and the tolerable level of decision errors for the study. The DQO process includes the following seven steps from EPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA 2006a):

- State the problem. Inadvertent release of contaminants into the environment.
- Identify the decision. Determine if accessible soil on DT-35 and DT-36 can be released in accordance with the SLDS ROD.
- Identify inputs to the decision. Sample data for accessible soil.
- Define the study boundaries. Accessible soil at DT-35 and DT-36.
- Develop a decision rule. See Table 3.
- Specify tolerable limits on decision errors. The minimum detectable concentration (MDC) for soil samples should be less than 50 percent of the RG. The MARSSIM evaluation should use decision errors where less than 5 percent of the decisions are falsely negative and less than 20 percent of the decisions are falsely positive. This means that the decision is more likely to conclude contamination is present when it is not, than to conclude that contamination is not present when it is.
- Optimize the design for obtaining data. For the PDI sampling, the sample grid and random sample locations were developed in anticipation that the sample results could be used for the FSS.

The FSS data were examined using Data Quality Assessment (DQA) guidance to ensure two things: (1) that the data met the quality requirements of the *Final Status Survey Plan for Accessible Soil within Mallinckrodt Property and the Vicinity Properties, Excluding Plants 1, 2, and the City Property at the St. Louis Downtown Site* (FSSP) (USACE 2002a), and the *Sampling and Analysis Guide for the St. Louis Sites (*SAG) (USACE 2000), and (2) that the data provided the necessary basis for determining whether the accessible soil on the properties meet ROD RGs and can be released. The DQA involves scientific and statistical evaluations to determine if data are of the right type, quality, and quantity to support the intended use. The DQA process is based on guidance from Chapter 8 and Appendix E in MARSSIM and follows EPA's *Data Quality Assessment: A Reviewer's Guide* (EPA 2006b). The five steps in the DQA process are listed below and are addressed by the subsequent report sections and appendices.

- Review the FSS design, including DQOs.
- Conduct a preliminary data review.
- Select a statistical test.
- Verify the assumptions of the statistical test.
- Draw conclusions from the data.

3.2 FINAL STATUS SURVEY PROCESS FOR SOIL

3.2.1 Final Status Survey Design for Soil

In accordance with MARSSIM, land areas receiving an FSS should be classified into Class 1, Class 2, or Class 3 soil SUs. The classification is based on their potential for radioactive contamination in accessible soils. Class 1 areas have the greatest potential for contamination, and Class 3 areas have the lowest potential. Per the FSSP, Class 1 SUs are typically limited in size to 2,000 m^2 plus ten percent, Class 2 SUs are typically limited in size to 10,000 m^2 plus ten percent, and Class 3 SUs are unlimited in size. MARSSIM states that Class 1 and 2 areas are to be sampled using a systematic grid, and that Class 3 areas are to be sampled using random locations.

Based on a review of site information and data, the land making up DT-35 was designated as a Class 2 area (SU-1), and DT-36 was designated as a Class 3 area (SU-2). There were no areas designated as a Class 1 area. The SUs are shown on Figure 3.

For the Class 2 area (SU-1), the location of systematic sample stations was based on a triangular grid pattern, extended from a random starting point. Per MARSSIM, triangular grids are generally more efficient for locating small areas of elevated radioactivity. Random sample locations were identified for the Class 3 area (SU-2). The random-start point for the systematic grid for Class 2 areas and the random locations for Class 3 areas are designed to ensure that the sample results are representative of the SU.

3.2.2 Final Status Survey Methodology for Soil

FSS sampling of soil involves collecting soil samples at the locations identified in the FSS design. Figure 3 depicts the sampling locations. These samples were collected from the top 0.5 ft bgs or within the top 0.5 ft of soil bcm (e.g., gravel).

Per the FSSP, subsurface soils were sampled to confirm that no unexpected subsurface radioactive contamination was present. These samples are generally taken at the same locations as the systematic surface samples. For Class 2 and 3 areas, the process for collecting subsurface samples for laboratory analysis starts with removing a soil column that is 1.5 to 2.0 ft long. A scan survey of the soil column is performed. The soil core length will be scanned with appropriate radiological survey instrumentation to identify the area within each sampling interval of the core having the highest instrument response. The soil within each sampling interval having the greatest response will be selected for sampling. Following the scan of the samples, the area of highest response will be further evaluated with appropriate radiological equipment for one minute and the results recorded in the logbook. If the soil in the sampling interval is determined to be homogeneous with regard to gamma and/or beta activity, then the bottom sampling interval will be selected for sampling and a one-minute fixed point measurement. The results of radiological screening will provide semi-quantitative data regarding the potential for elevated radiological COCs in soil cores.

One-third of the locations should continue this process for each 1.5 to 2.0 ft soil column to a depth of 6 ft bgs. Each subsurface sampling hole was abandoned using bentonite.

MARSSIM also recommends performing radiation scans of the ground surface (with any cover material). The size of the area surveyed for Class 2 areas should be 10 to 100 percent (proportional to the potential for finding areas of elevated radioactivity). For Class 3 areas, the size of the area should be based on the professional judgment of the survey supervisor (typically

Using this concept of inaccessible soils, there are inaccessible soils associated with the buildings on DT-35 and DT-36, as shown on 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. The inaccessible soils associated with these structures will be evaluated in subsequent CERCLA actions.

Table 3. Remediation Goals and Assessment Methods

<table>
<tr><th>Type</th><th colspan="2">Specification</th><th>Methods</th></tr>
<tr><td rowspan="5">Soil Radionuclide

(Results from a 0.5 ft soil interval can be averaged over 100 m^2.)</td><td>Ra-226
Th-230</td><td><5 picocurie per gram (pCi/g) above background for soil less than 0.5 ft below cover material (bcm)
<15 pCi/g above background for soil deeper than 0.5 ft bcm</td><td rowspan="5">Use sample results to calculate the net sum-of-the-ratio (SOR_N) and gross sum-of-the-ratio (SOR_G). Calculate area-weighted averages as necessary. Use MARSSIM to determine the required number of systematic or random samples.</td></tr>
<tr><td>Ra-228
Th-232</td><td><5 pCi/g above background for soil less than 0.5 ft bcm
<15 pCi/g above background for soil deeper than 0.5 ft bcm</td></tr>
<tr><td>U-238</td><td><50 pCi/g above background for soil</td></tr>
<tr><td>SOR_N</td><td>$SOR_N^{depth \leq 0.5ft} = \frac{(greater\ of\ Th\text{-}230_N\ or\ Ra\text{-}226_N)}{5\ pCi/g} + \frac{(greater\ of\ Th\text{-}232_N\ or\ Ra\text{-}228_N)}{5\ pCi/g} + \frac{U\text{-}238_N}{50\ pCi/g}$
$SOR_N^{depth\ 0.5\text{-}6ft} = \frac{(greater\ of\ Th\text{-}230_N\ or\ Ra\text{-}226_N)}{15\ pCi/g} + \frac{(greater\ of\ Th\text{-}232_N\ or\ Ra\text{-}228_N)}{15\ pCi/g} + \frac{U\text{-}238_N}{50\ pCi/g}$
$SOR_N < 1$ over 100 m^2 using area-weighted average
$SOR_N < 1$ when systematic sample results averaged over survey unit (SU)</td></tr>
<tr><td>SOR_G</td><td>Pass MARSSIM Wilcoxon Rank Sum (WRS) test</td></tr>
<tr><td>Soil Non-Radionuclide</td><td colspan="3">Not applicable (N/A)</td></tr>
<tr><td>Consolidated Material Surfaces</td><td colspan="3">N/A</td></tr>
<tr><td>Health Risk</td><td colspan="2">10^{-6} to 10^{-4}</td><td rowspan="2">For radioactivity, use sample results as inputs to the Residual Radioactivity (RESRAD) computer model to estimate health risk</td></tr>
<tr><td>Dose</td><td colspan="2">Total Effective Dose Equivalent (TEDE) < 25 millirem/year (mrem/yr)</td></tr>
<tr><td>Toxicity</td><td colspan="3">N/A</td></tr>
</table>

Notes:

In the SOR_N equations, the radioactivity (e.g., Ra-226) is measured as a concentration (i.e., pCi/g). The radioactivity concentration is divided by the RG for that specific radionuclide (e.g., 5 pCi/g for Ra-226). The subscript "N" represents net concentration above background. Background values were determined using 32 samples collected from non-impacted areas near the SLDS. The background reference sample data is summarized in Appendix A.

The SLDS ROD lists RG components that address groundwater monitoring of the Mississippi Alluvial Aquifer (B unit). This aquifer is addressed separately from this report on accessible soil.

The SLDS ROD lists RG components that address institutional controls for areas that cannot be released. Those RGs are not applicable to the accessible soil discussed in this report.

The SLDS ROD lists an RG component that addresses accessible sewer and drain sediments. DT-35 and DT-36 do not have accessible sewers or drains.

2.1.4 Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA and National Contingency Plan (NCP) §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations, which are about 10 percent of the area). These radiation scans are called gamma walkover surveys (GWSs). The GWSs are used to select biased sample locations as an additional effort to locate areas requiring further investigation and ensure that the systematic samples are representative of the SU. Additional information on GWS is in Appendix B.

The biased sample locations determined from the GWS are designated with the "HTZ" prefix and are assigned an area, in square meters, that the sample represents. (The "HTZ" prefix can also be used for biased samples that are taken to bound the extent of contaminated soil, but no areas are assigned to these HTZ samples.) The biased sample locations are shown on Figure 3. GWS-based biased surface samples were collected within the upper 0.5 ft of the surface soil bcm.

Two additional biased sampling locations were selected at DT-35 and one additional biased sampling location was selected at DT-36 to investigate the potential for deposition of radioactive contamination at downspout locations. In addition, a subsurface sample was collected from 1.5-2.0 ft bcm at the downspout sample locations. The sample locations are shown on Figure 3.

3.2.3 Final Status Survey Methodology for Asphalt

When soil sampling was performed in an area covered by asphalt an asphalt plug was removed to allow access to the underlying soil. The area of the asphalt plug that was in contact with the soil was subjected to a radiological survey. The results of the radiological surveys were comparable to background levels.

The asphalt on DT-35 and DT-36 was not subjected to laboratory analysis. The determination that asphalt did not require analysis is based on the asphalt sample results from Plants 1 and 2 at the SLDS. The soil under the asphalt on Plants 1 and 2 had some of the highest contamination found anywhere on the SLDS. However, sampling results showed that the asphalt had not become contaminated from the soil it was covering.

4.0 ASSESSMENT OF FINAL STATUS SURVEY RESULTS

4.1 ASSESSMENT OF SOIL SAMPLE RESULTS

The soil sample results are reported in Appendix C. A copy of the field logbook entries for these samples is on the CDROM on the back cover of this report. The surface and subsurface RGs were applied as follows to calculate the SOR_N.

- SOR_N using surface RGs: If no cover material was present, then the sample was collected from the upper 0.5 ft of the soil. If cover material was less than 0.5 ft, then the sample was collected from the first 0.5 ft of soil bcm.
- SOR_N using subsurface RGs: The sample was collected from below 0.5 ft of the ground surface.

The sample data for each soil SU were evaluated to ensure the average SOR_N over the entire SU did not exceed one. The mean systematic or random sample SOR_N for the soil SUs were below one, ranging from 0.01 to 0.12. Since the mean SOR_N values were less than one, the radionuclide RGs were met for each SU. The data are summarized in Appendix D.

In addition to a direct comparison to the RGs, MARSSIM recommends that an investigation level be established to investigate results that pass the statistical test, but potentially represent the edge of more significant contamination. MARSSIM identifies the DCGL, which is an SOR_N of one for this report, as the investigation level for Class 2 areas. MARSSIM identifies a fraction of the DCGL as the investigation level for Class 3 areas. An SOR_N of 0.30 was used as the investigation level for Class 3 areas for this report. No samples required further investigation. The analysis did not identify any conditions where the RGs were exceeded.

In compliance with the FSSP requirement that at least one-third of the sample stations be sampled to 6 ft, 7 of the 17 sample locations (SLD95127, SLD95135, SLD95145, SLD95151, SLD95301, SLD95305, and SLD95309) were sampled to a depth of 6 ft.

4.1.1 Statistical Test for Soil Sample Results

Per MARSSIM, the Wilcoxon Rank Sum (WRS) test is used in situations where the radiological COCs are present in background soils and establishes with sufficient statistical probability that the average concentration in the SU does not exceed the RG. MARSSIM also states that "if the difference between the largest SU measurement and the smallest reference area measurement is less than or equal to the DCGL [i.e., $SOR_G^{max\ systematic\ or\ random} - SOR_G^{min\ reference} < 1.0$], the WRS will always show the SU meets the release criterion." This means that for every SU that meets the above calculation the WRS test is not necessary.

From the SLDS reference area data sets, the minimum surface SOR_G is 0.53 and the minimum subsurface SOR_G is 0.19 (See Appendix A). (Background values are not subtracted in the SOR_G calculation.) For soil SU-1 and SU-2, this difference was always less than one (e.g., for SU-1, 1.44 - 0.53 = 0.91). Therefore, a WRS test for these SUs is not necessary. The SOR_G values for SU-1 and SU-2 can be found in Appendix D. SU-1 and SU-2 are shown on Figure 3.

4.1.2 Asphalt Survey Results

There were no radiological survey results above background levels for any of the asphalt plugs that were removed to allow access for sampling the soil underneath the asphalt.

4.1.3 Review of Final Status Survey Design for Soil

An important factor in MARSSIM is determining an appropriate number of systematic or random samples for the statistical test. Collecting too few samples can result in an inaccurate conclusion. Collecting an excessive number of systematic or random samples diverts resources that could be better used elsewhere. MARSSIM establishes a method for determining the minimum number of systematic or random samples. For example, at a minimum one sample is collected for each 100 m^2 that make up a Class 1 area. Appendix E contains the detailed process for determining the minimum number of systematic or random samples. The calculated minimum number of systematic or random sample for SU-1 and SU-2 is 7 and 5 samples, respectively. The actual number of FSS samples collected for SU-1 and SU-2 was 11 and 5 samples, respectively. Therefore, a sufficient number of samples were taken

4.2 DATA QUALITY

Quality control (QC) and quality assurance (QA) measures for FSS data are summarized in the FSSP and are presented in the QA and QC sections of the SAG. The Quality Control Summary Report (QCSR) in Appendix F discusses these measures in detail for DT-35 and DT-36. The FSS data met QA and QC requirements.

4.2.1 Minimum Detectable Concentration for Soil Samples

Soil samples were analyzed in a laboratory in order to measure the radioactivity at very low levels. In general, the minimum detectable concentration (MDC) represented the lowest level that the laboratory achieved for each sample given a set of variables including detection efficiencies and conversion factors due to influences such as individual sample aliquot, sample density, and variations in analyte background radioactivity at the laboratory. The MDC was reported with each sample result in Appendix C.

MARSSIM recommends that analytical methods should be capable of measuring levels at 10-50 percent of the established RG. The FSSP states a preferred target MDC of 10 percent of the RG. These MDC limits for surface soils are listed in Table 4.

Table 4. Minimum Detectable Concentration Limits

Radionuclide	MDC (pCi/g)	Preferred MDC(pCi/g)
Ra-226/Th-230	2.5	0.5
Ra-228/Th-232	2.5	0.5
U-238	25	5.0

All of the FSS sample MDCs were less than 10 percent for each of the individual radionuclide RGs, thus meeting the MARRSIM recommendation and the FSSP requirement. As discussed in MARSSIM, the reported radionuclide concentrations from the laboratory were used in this FSSE even if those results were below the MDC. These data were used to complete the MARSSIM evaluation and assess the risk and dose for the SUs.

5.0 RESIDUAL RISK AND DOSE ASSESSMENT

A property-specific residual risk and dose assessment was performed for DT-35 and DT-36 in accordance with the SLDS ROD to confirm that conditions are protective of human health and the environment. The SLDS ROD established the CERCLA target risk range as the risk RG and the benchmark dose limit of 25 mrem/yr as the dose RG for the SLDS. The EPA 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 10^{-4}. A specific risk estimate around 10^{-4} may be considered acceptable if justified based on site-specific conditions" per memorandum OSWER 9200.4-18 "*Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*" (EPA 1997a).

The risk and dose scenario for the SLDS ROD is based on the industrial worker and utility worker exposure scenarios defined in the SLDS FS. The assessment for DT-35 and DT-36 was performed for each of these scenarios, and an additional on-site residential scenario was considered at the request of the regulators.

CERCLA recommends a lifetime exposure assessment period of 30 years for individuals under a residential exposure scenario. 40 CFR 192 Subpart A requires a 1,000 year exposure assessment scenario that takes into account the risk posed by residual levels of long-lived radionuclides and the in-growth of their decay products. This time period considers the period of time over which achievement of the cleanup standard must be reasonably assured.

Section C.2.1.3 of the SLDS FS states: "To estimate a dose or risk, the appropriate exposure parameters, the source term (concentrations of radionuclides), and other variables such as depth of contamination and distribution coefficients are selected to provide conservative yet realistic estimates of exposure." This means that the actual risk and dose received by an individual from residual MED/AEC material on these properties will be lower than the estimates in this assessment. Additionally, much of the properties were covered by asphalt, concrete, or gravel. These cover materials provide additional protection that is not accounted for in the estimates. This is another example of how the actual MED/AEC-related risk and dose will be lower than the estimates provided in this assessment.

The results of systematic, random, biased, and subsurface samples were used in the residual risk and dose assessment. The risk and dose estimates are provided in Table 5.

Table 5. Risk and Dose Estimate

Scenario	Period Assessed (years)	Maximum Risk	Maximum Dose (mrem/yr)
Industrial Worker	0 to 1,000	$2x10^{-5}$	1
Utility Worker	0 to 1,000	$3x10^{-5}$	0
On-Site Resident	0 to 1,000	$7x10^{-5}$	3
On-Site Resident with 6 inches of cover	0 to 1,000	$3x10^{-5}$	2

Based on the results of risk and dose assessments, it can be concluded that residual risk and dose for accessible soil at DT-35 and DT-36 are protective for all of the receptor scenarios (including on-site resident), are protective of public health and the environment, and the accessible soils on the properties can be released. More information on how these values were calculated is provided in Appendix G.

6.0 CONCLUSIONS

The conditions established in the SLDS ROD for protecting human health and the environment have been met for the accessible soils on DT-35 and DT-36. This conclusion is the result of a comparison of the SLDS ROD requirements and the current conditions, as presented in Table 6. The survey results and the risk and dose assessment demonstrate that the accessible soils on DT-35 and DT-36 can be released in accordance with the SLDS ROD.

Table 6. Comparison of Results to Remediation Goals

RG Type	Specification	Results
Soil Radionuclide (Note: 40 CFR 192 allows area-weighted averaging over a 0.5 ft layer of soil.)	Sample $SOR_N \leq 1$ when averaged over 100 m^2. $SOR_N < 1$ when systematic sample results averaged over SU. Pass MARSSIM WRS test.	The highest sample SOR_N was 0.94. SU-1: Average SOR_N=0.12 SU-2: Average SOR_N=0.01 WRS test not required (see Section 4.1.1).
Health Risk	10^{-6} to 10^{-4}	7×10^{-5}
Dose	TEDE < 25mrem/yr	3 mrem/yr

The main components of the SLDS ROD Selected Remedy are repeated below (i.e., bullet/italicized items) along with a brief summary of conclusions drawn from this report.

- *Excavation of accessible soils according to the* [applicable or relevant and appropriate requirement] *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).

  FSS data has confirmed that no accessible soils have been left in place at DT-35 and DT-36 with contamination above RGs. Excavation was not required.

- *On the portion of the Mallinckrodt property addressed 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).

  Not applicable. Deep-soil RGs do not apply to DT-35 and DT-36 because remedial action was not required.

- *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

  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).

  Not applicable. Non-radiological 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).

FSS data has confirmed that no accessible soils have been left in place at DT-35 and DT-36 with contamination above RGs. This statement in the SLDS ROD is true for SU-1 and SU-2. The SOR_G (the raw data including background) are also less than 1.0 when averaged across the each SU. Non-radiological requirements are not applicable to DT-35 and DT-36.

- *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 DT-35 and DT-36. Chemical analysis is not applicable to the 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 SLDS 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 DT-35 and DT-36 meet the criteria stated in the SLDS ROD.

- *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 accessible areas of DT-35 and DT-36 without restrictions. There are no accessible areas on either property where it is necessary to apply use restrictions or institutional controls.

- *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 accessible areas of DT-35 and DT-36 without use restrictions. There are no accessible areas at DT-35 and DT-36 where it is necessary to apply use restrictions or institutional controls.

- *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 the SLDS has been implemented to confirm expectations that significant impacts to the Mississippi Alluvial Aquifer (B unit) will not occur.

- *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, ground water monitoring wells in the Mississippi Alluvial Aquifer are being monitored at the SLDS.

- *Protactinium (Pa)-231 and Actinium (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.

7.0 CONTACT INFORMATION

Contact information for the primary project team participants is provided below.

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FIGURES

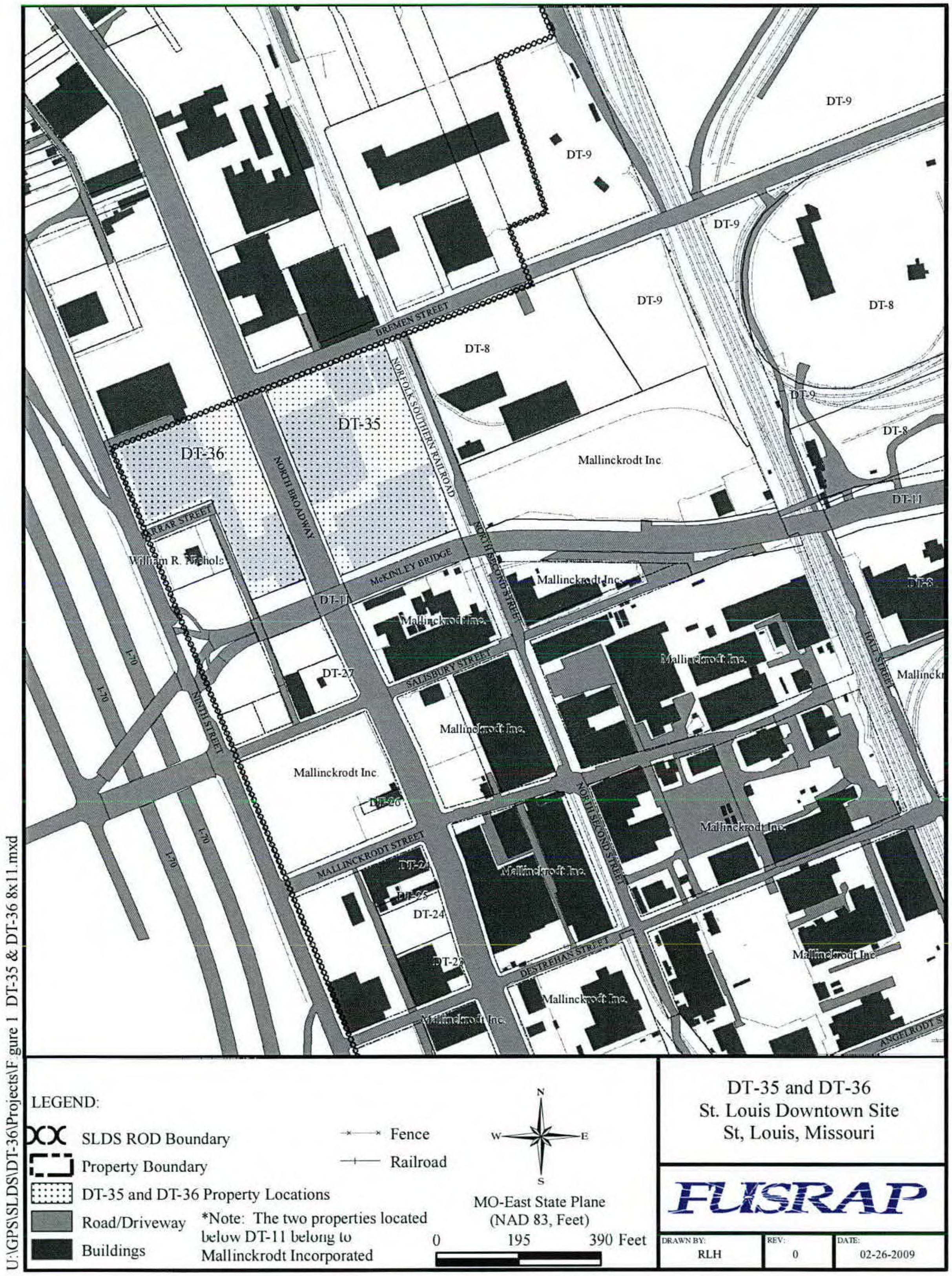

Figure 1. DT-35 and DT-36 Vicinity Properties

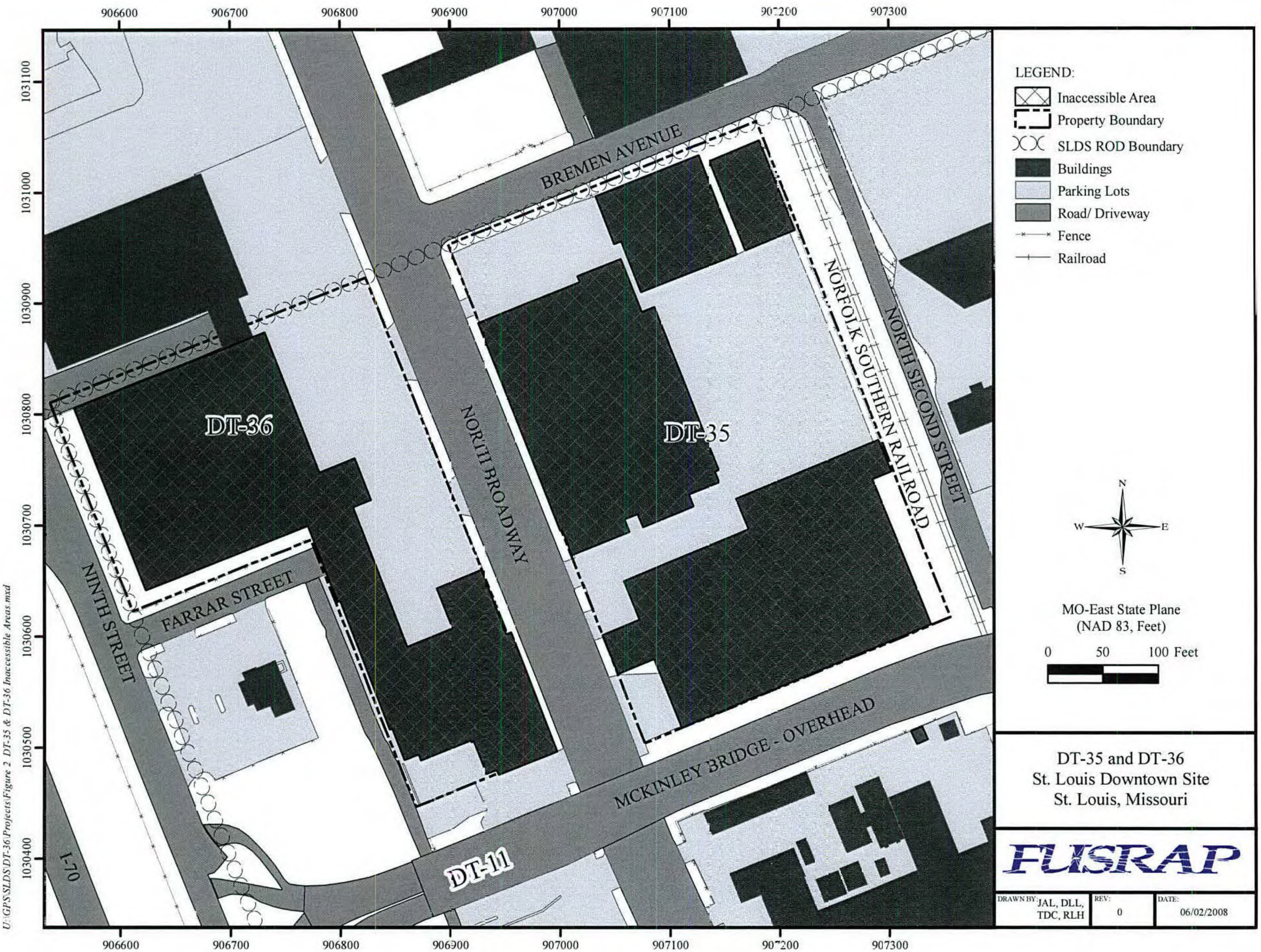

Figure 2. DT-35 and DT-36 Inaccessible Areas

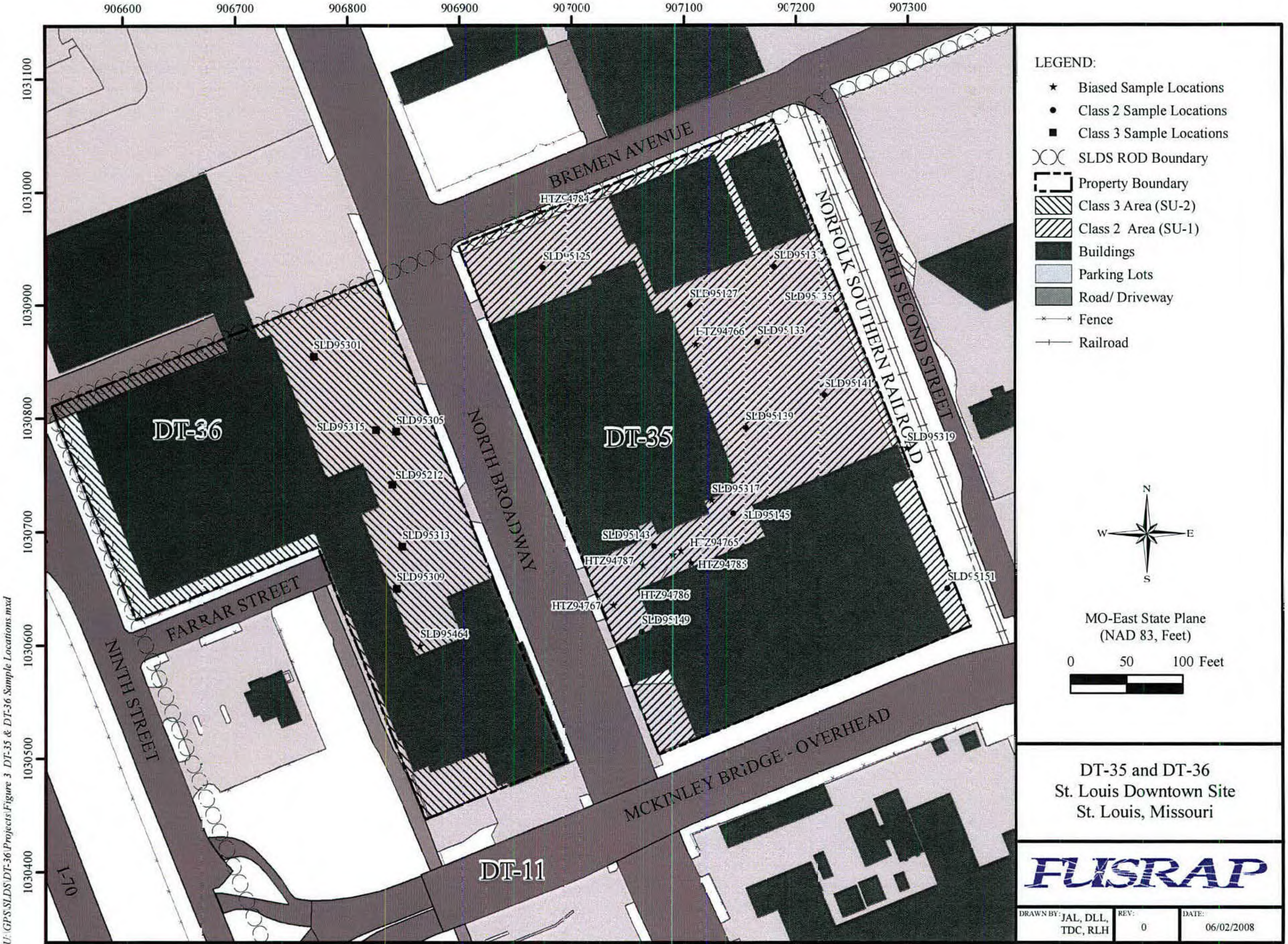

Figure 3. DT-35 and DT-36 Sample Locations

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APPENDIX A

BACKGROUND REFERENCE SOIL SAMPLE DATA

(On the CDROM on the Back Cover of this Report)

Table A-1. Background Reference Soil Data

Background Reference Subsurface Soil Data Summary (32 Samples)											
Statistic	**Ac-227**	**Pa-231**	**Ra-226**	**Ra-228**	**Th-228**	**Th-230**	**Th-232**	**U-235**	**U-238**	**Surf. SOR_G**	**Sub. SOR_G**
Mean	0.14	0.89	2.78	0.95	1.16	1.94	1.09	0.10	1.44	0.82	0.29
Median	0.11	0.98	2.53	0.97	1.10	1.66	1.07	0.09	1.16	0.76	0.27
Std. Dev.	0.14	0.76	0.89	0.17	0.35	0.76	0.29	0.08	0.75	0.21	0.08
Maximum	0.70	2.34	5.46	1.28	2.10	4.15	1.68	0.31	3.78	1.48	0.54
Minimum	-0.10	-0.21	1.53	0.46	0.51	0.96	0.43	-0.02	0.59	0.53	0.19
Range	0.80	2.55	3.93	0.82	1.59	3.19	1.25	0.33	3.19	0.95	0.35

Background Reference Soil Sample Results											
Statistic	**Ac-227**	**Pa-231**	**Ra-226**	**Ra-228**	**Th-228**	**Th-230**	**Th-232**	**U-235**	**U-238**	**Surf. SOR_G**	**Sub. SOR_G**
SLD00001	0.18	0.62	1.94	0.97	1.29	2.07	1.11	0.25	1.66	0.67	0.25
SLD00002	-0.03	2.34	2.39	1.03	1.08	1.67	1.12	0.00	0.61	0.71	0.25
SLD00022	0.36	1.33	2.56	1.17	1	1.83	1.49	0.24	1.38	0.84	0.30
SLD00023	0.29	0.95	2.26	0.76	0.51	2.80	1.23	0.00	1.17	0.83	0.29
SLD00041	0.16	-0.09	2.48	0.84	0.77	1.98	1.13	0.17	1.57	0.75	0.27
SLD00042	0.70	-0.02	3.02	1.07	1.14	2.24	1.05	0.00	1.80	0.85	0.31
SLD00043	0.28	2.07	2.59	0.99	1.24	2.69	1.68	0.11	1.15	0.90	0.31
SLD00044	0.13	1.65	3.46	1.03	1.06	1.16	1.33	0.00	0.90	0.98	0.34
SLD00061	0.10	1.23	3.11	1.08	1.02	2.67	1.43	-0.01	1.47	0.94	0.33
SLD00062	0.12	1.36	2.59	1.28	1.29	1.91	1.59	0.11	0.94	0.85	0.30
SLD00063	0.15	2.12	2.11	1.03	1.01	1.61	0.70	-0.02	0.74	0.64	0.22
SLD00081	0.24	0.98	2.44	0.96	1.46	1.47	1.30	0.12	1.05	0.77	0.27
SLD00082	0.06	1.19	2.89	1.28	2.1	1.97	1.17	0.18	1.28	0.86	0.30
SLD00083	0.20	0.98	2.33	0.88	1.6	1.94	0.69	0.11	0.59	0.65	0.23
SLD00101	0.15	1.01	4.24	0.79	1.12	3.05	0.90	0.22	3.12	1.09	0.41
SLD00102	0.06	1.42	3.53	0.86	1	3.11	1.41	0.08	2.53	1.04	0.38
SLD00103	0.08	1.30	3.08	0.81	0.54	1.46	0.92	0.05	1.69	0.83	0.30
SLD00121	0.17	-0.10	3.31	0.87	1.27	2.25	1.34	0.31	1.84	0.97	0.35
SLD00122	0.09	0.42	2.68	0.85	1.69	1.46	0.94	0.06	1.13	0.75	0.26
SLD00123	0.23	0.25	3.51	1.02	1.23	1.33	0.94	0.06	1.17	0.93	0.33
SLD00141	0.16	-0.21	5.46	1.04	1.4	4.15	1.56	0.07	3.78	1.48	0.54
SLD00142	0.08	0.33	5.30	1.12	1.74	3.61	1.04	0.16	3.15	1.35	0.49
SLD00143	0.19	0.02	2.33	0.96	1.5	1.45	1.02	0.05	0.93	0.69	0.24
SLD00144	0.10	0.01	2.04	1.10	1.51	1.48	1.25	0.17	1.61	0.69	0.25
SLD00161	0.10	0.11	1.53	0.86	1.38	1.56	1.01	0.10	1.11	0.54	0.19
SLD00162	0.04	2.01	2.07	1.04	0.73	1.35	0.86	0.12	1.00	0.64	0.23
SLD00181	0.03	1.13	2.24	0.73	0.94	1.34	0.78	0.00	0.91	0.62	0.22
SLD00201	0.06	1.74	2.40	0.86	1.07	1.64	1.08	0.10	1.15	0.72	0.26
SLD00202	-0.10	1.73	2.67	0.97	0.88	1.62	0.78	0.05	1.11	0.75	0.26
SLD00241	0.01	-0.04	2.04	0.46	0.87	1.28	0.43	0.11	1.70	0.53	0.20
SLD00242	0.07	0.42	2.50	0.89	0.8	1.05	0.80	0.00	0.92	0.70	0.24
SLD00243	0.03	0.37	1.97	0.65	0.84	0.96	0.90	0.08	0.86	0.59	0.21

Note:

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

Negative results are less than the laboratory system's background level.

APPENDIX B

GAMMA RADIATION WALKOVER SURVEY

GAMMA RADIATION WALKOVER SURVEY

Many radioactive contaminants can be identified through field detection methods such as surface gamma radiation scans. (Field detection methods are generally not available for detection of non-radioactive contaminants, which solely rely on laboratory analysis of field samples.) While radioactive contaminants that emit gamma radiation can be detected through radiation scans, the contaminants are not the only radioactivity that may be detected. The gamma scans detect radiation from both naturally-occurring sources and environmental contamination, and both are present in the GWS results.

GWS is a qualitative tool that can help locate radioactive contamination. However, elevated GWS readings do not in and of themselves provide a definitive indication that the RGs are exceeded. There are no RGs specifying an unacceptable GWS result. Where there are higher levels of naturally-occurring radioactivity, higher GWS readings will occur even though the RGs are met. Such readings can be thought of as false positive results. Representative biased samples are collected and analyzed in a radioanalytical laboratory to investigate areas identified during the GWS. These areas are investigated to ensure the RGs are met in those areas. Unlike the GWS, the analytical laboratory can quantitatively identify the COCs for comparison to the RGs.

Before starting the GWS, the professional health physics technicians established the relative background radiation level in counts per minute (cpm) for the specific survey area with the survey instrument being used. During the GWS, the technicians assessed the count rates displayed on the instrument and the associated audible click rates to identify locations (by paint or flag) from which representative biased samples should be obtained. The identified locations had radiation readings that typically exceeded the relative background radiation levels by 2,000 cpm or higher. Then, professional health physicists reviewed the results of the GWSs and defined locations from which any additional representative biased samples were collected.

This review considered count rates, mathematical analysis of the count rates, existing sample information in the area(s) of interest, increased radiation from materials with higher concentrations of natural-occurring radioactivity (such as granite, brick, some concrete, coal or coal ash, and road salt), increased radiation from soil located perpendicular to the surveyed surface (such as the side wall to an excavation or a hill or mound), attempts to duplicate higher count rates, and experience with variations in the radiation readings of soil. As an example of the wide variation of naturally-occurring radioactivity in soil, the laboratory results for soil samples collected to establish background levels for the SLDS identified some samples with isotopic concentrations that were nearly twice the average.

Four biased samples were collected for this FSSE based on the GWS. *All of these biased samples met the RGs.*

The GWS figures were developed by using a geographic information system. The GWS results in count rates and the location coordinates were translated into maps of colored data points. The range for the colors was calculated using the mean and standard deviation of the count rate from each GWS. The calculation also factors at what count rate a surveyor can distinguish an overall increase in fluctuating readings from the general level of fluctuating readings. The factor is calculated using equations from the *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, NUREG 1507 (Nuclear Regulatory Commission [NRC] 1998).

Since MARSSIM identifies that environmental data does not generally fit a normal distribution and uses non-parametric tests, Chebyshev's Inequality was used for setting the ranges of the colors for the GWS data. The 85th and 95th percentile of the data were chosen to focus on areas of interest with higher cpm. The 85th percentile means that 85 percent of the data have values less than the 85th percentile value; the 95th percentile is similarly defined. To achieve the 85th percentile of the data, a 1.83 factor for the standard deviation was calculated for each GWS file using Chebyshev's Inequality. To achieve the 95th percentile of the data, a 3.15 factor for the standard deviation was calculated using Chebyshev's Inequality. The NUREG 1507 factor for fluctuating readings was added to these percentile values to determine the color set points for each GWS file.

The area represented by red on the GWS figures indicates an area of interest. However, not every red data point is sampled. In some cases, elevated levels are due the presence naturally-occurring radioactivity in granite blocks and red bricks, as labeled on Figures B-1 and B-2.

The global positioning system used for the GWSs has inherent variability in identifying location coordinates. Some of the GWS and samples may be or appear to be outside the subject property or SU boundary due to structural interferences, samples being taken in the sloped wall of an excavation, and/or variance in the global positioning system and the geographical information system. Some sample station coordinates were obtained at a time different than the time that the GWS was performed and the sample locations were painted or flagged. Thus, samples and their corresponding elevated GWS readings may have different coordinates and may be separated by several feet on the figures when in reality they are in the same location.

The GWS instruments and their detection sensitivities are listed in Table B-1 below. Detection sensitivities were determined following the guidance of NUREG 1507, and are derived in the FSSP. The sensitivities presented were derived using typical instrument parameters and are well below the RGs for soil, with the exception of Th-230. Since Ra-226 and Th-230 are commingled, Ra-226 was used as a surrogate for Th-230. For each survey unit, the ratio of Ra-226 and Th-230 was confirmed to be high enough for Ra-226 to be a surrogate for Th-230 so Th-230 would be identified at levels below its RG.

Field instrumentation was calibrated annually and source checked daily during use. In addition, daily field performance checks were conducted in accordance with instrument use procedures. The performance checks were conducted prior to initiating the daily field activities, upon completion of daily field activities, and if the instrument response appeared questionable.

Table B-1. Radiological Field Instrument Detection Sensitivity

Description	Application	Detection Sensitivity	
Ludlum Model 2221 with a Ludlum Model 44-10 (2" × 2" sodium iodide gamma scintillation detector)	Gamma scans of ground surface and cover material	Ra-226 Th-230 U-natural	1.2 pCi/g 1,120 pCi/g 40 pCi/g

APPENDIX B

FIGURES

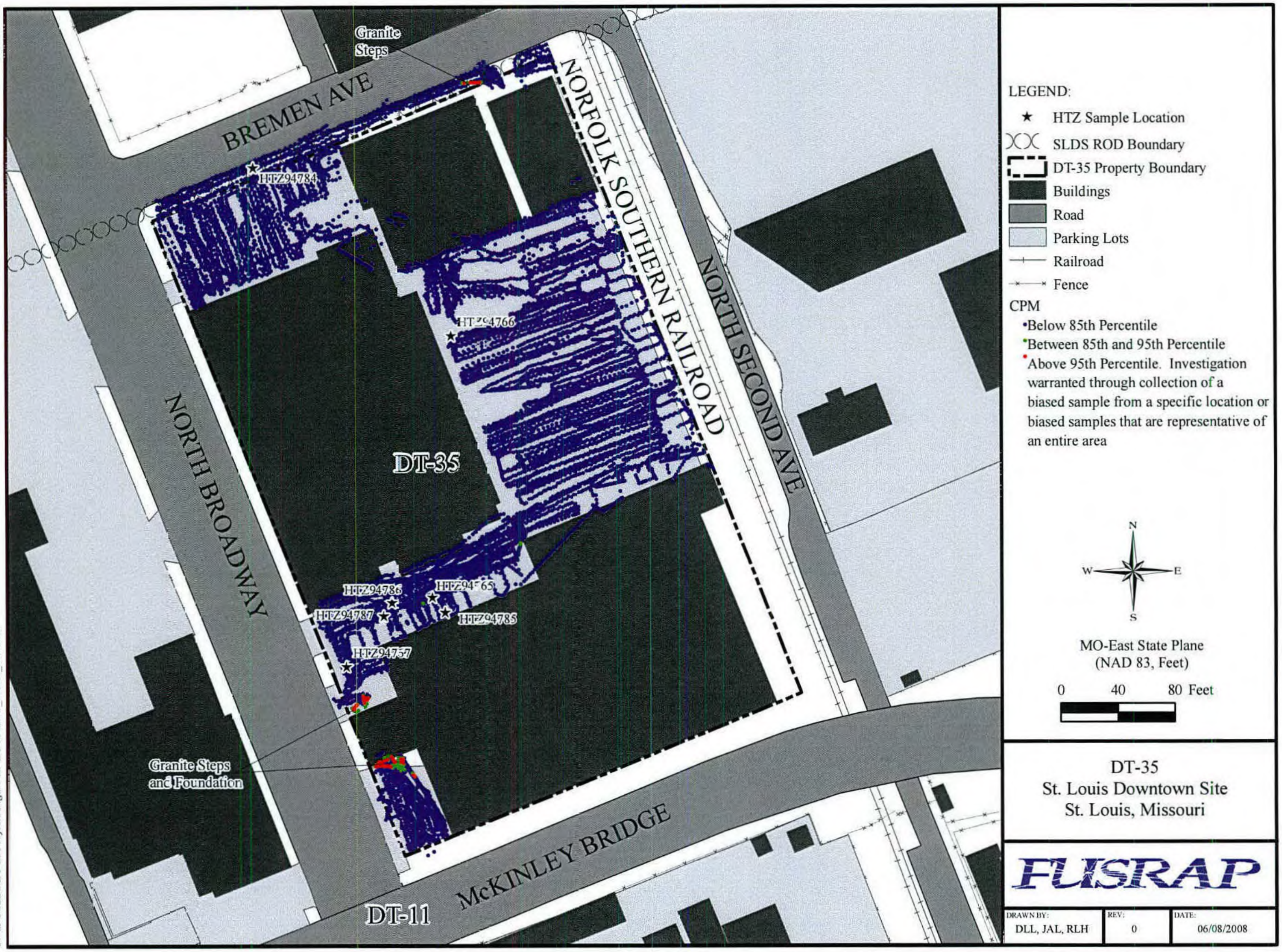

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Figure B-1. DT-35 Gamma Walkover Survey

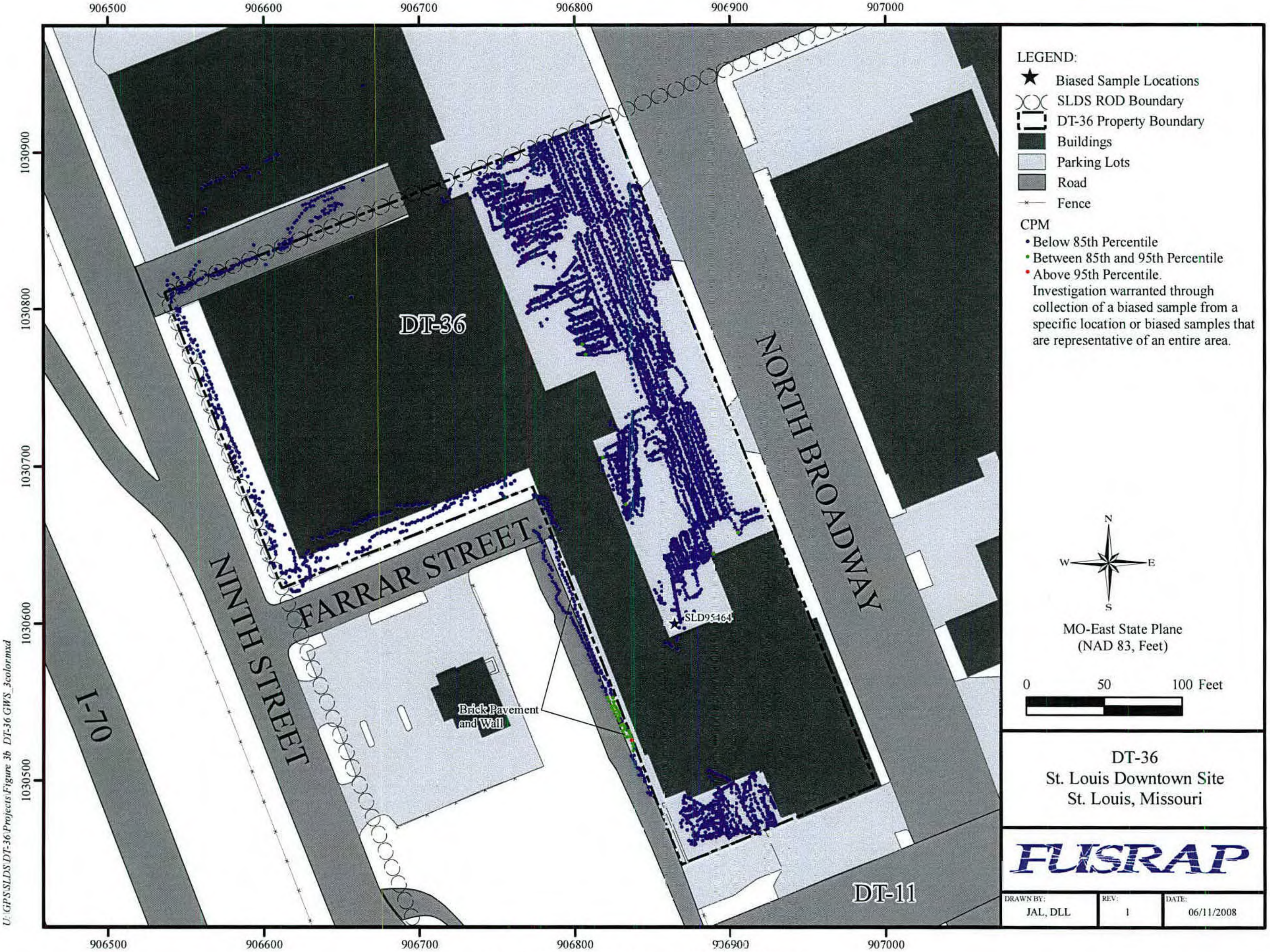

Figure B-2. DT-36 Gamma Walkover Survey

APPENDIX C

FINAL STATUS SURVEY SOIL SAMPLE DATA

(On the CDROM on the Back Cover of this Report)

(Copies of Logbook Entries for these Samples Are on the CDROM on the Back Cover of this Report)

Table C-1. DT-35 Final Status Survey Soil Sample Data

Station Name	Sample Name	Easting	Northing	Ac-227				Pa-231				Ra-226				Ra-228				Th-228				Th-230				Th-232				U-235				U-238			
				Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ
HTZ94765	HTZ94765	907097	1030684	0.30	0.32	0.48	UJ	0.17	0.83	1.24	UJ	5.69	1.34	0.12	=	1.15	0.10	0.14	=	1.68	0.75	0.38	=	6.22	1.82	0.17	=	1.27	0.63	0.17	=	0.38	0.39	0.64	UJ	3.53	1.20	1.50	=
HTZ94766	HTZ94766	907110	1030865	-0.15	0.38	0.59	UJ	0.60	1.07	1.70	UJ	1.29	0.40	0.16	=	1.23	0.16	0.21	=	1.06	0.48	0.26	=	1.63	0.61	0.22	=	1.51	0.58	0.12	=	0.18	0.43	0.72	UJ	3.02	1.82	1.03	J
HTZ94767	HTZ94767	907036	1030636	0.06	0.16	0.28	UJ	0.09	0.51	0.76	UJ	1.43	0.37	0.07	=	0.57	0.06	0.10	=	0.98	0.48	0.25	=	3.68	1.11	0.14	=	0.60	0.36	0.14	J	-0.13	0.22	0.34	UJ	2.04	1.01	0.88	=
HTZ94784	HTZ94784	906972	1030983	-0.05	0.12	0.19	UJ	0.06	0.37	0.52	UJ	1.13	0.28	0.04	=	0.77	0.05	0.06	=	1.27	0.57	0.26	=	1.28	0.57	0.14	=	0.82	0.44	0.14	J	0.00	0.14	0.24	UJ	0.94	0.44	0.41	=
HTZ94785	HTZ94785	907106	1030673	0.12	0.16	0.24	UJ	0.09	0.43	0.61	UJ	3.90	0.90	0.06	=	0.67	0.05	0.06	=	1.18	0.63	0.19	J	4.91	1.59	0.35	=	1.02	0.58	0.35	J	0.06	0.20	0.34	UJ	2.56	0.57	0.52	=
HTZ94786	HTZ94786	907090	1030680	0.07	0.17	0.24	UJ	0.10	0.44	0.62	UJ	3.53	0.81	0.06	=	0.68	0.05	0.07	=	0.68	0.41	0.27	J	3.46	1.10	0.14	=	1.12	0.53	0.14	=	0.18	0.20	0.33	UJ	3.17	0.54	0.54	=
HTZ94787	HTZ94787	907063	1030671	0.26	0.23	0.28	U	0.34	0.51	0.77	UJ	3.98	0.92	0.07	=	0.80	0.06	0.09	=	1.32	0.61	0.16	=	3.75	1.20	0.16	=	1.09	0.55	0.16	J	0.25	0.16	0.35	U	3.27	0.63	0.52	=
SLD95125	SLD95125	906974	1030933	-0.02	0.15	0.24	UJ	0.06	0.43	0.65	UJ	1.41	0.35	0.06	=	0.78	0.06	0.08	=	1.00	0.50	0.14	=	1.73	0.69	0.14	J	0.51	0.35	0.26	J	0.11	0.18	0.31	UJ	1.34	0.60	0.45	J
SLD95125	SLD95126	906974	1030933	0.05	0.14	0.23	UJ	0.03	0.42	0.59	UJ	1.99	0.48	0.06	=	0.76	0.05	0.06	=	1.10	0.53	0.35	=	2.60	0.89	0.14	J	0.67	0.40	0.14	J	0.21	0.17	0.30	U	1.50	0.55	0.47	J
SLD95127	SLD95127	907105	1030914	0.04	0.15	0.25	UJ	0.01	0.44	0.66	UJ	2.06	0.50	0.07	=	0.80	0.06	0.09	=	1.20	0.60	0.31	=	3.17	1.10	0.17	=	1.09	0.56	0.17	J	0.39	0.20	0.31	J	4.47	0.66	0.50	=
SLD95127	SLD95128	907105	1030914	-0.01	0.17	0.27	UJ	0.31	0.48	0.75	UJ	2.52	0.61	0.07	=	0.93	0.07	0.10	=	0.91	0.45	0.13	=	1.92	0.71	0.13	=	1.01	0.48	0.13	=	0.12	0.21	0.36	UJ	2.15	0.65	0.54	=
SLD95127	SLD95129	907105	1030914	-0.21	0.19	0.28	UJ	0.19	0.54	0.83	UJ	1.66	0.42	0.08	=	1.04	0.08	0.11	=	1.49	0.61	0.24	=	2.07	0.75	0.24	=	0.97	0.47	0.13	=	-0.08	0.23	0.38	UJ	1.88	0.75	0.57	=
SLD95127	SLD95130	907105	1030914	0.02	0.18	0.26	UJ	-0.02	0.49	0.73	UJ	1.36	0.35	0.07	=	1.13	0.08	0.10	=	1.37	0.57	0.23	=	1.66	0.64	0.13	=	1.42	0.58	0.23	=	0.04	0.20	0.34	UJ	1.70	0.59	0.51	=
SLD95131	SLD95131	907176	1030943	0.00	0.17	0.27	UJ	0.66	0.48	0.77	U	2.52	0.61	0.07	=	0.97	0.07	0.10	=	1.11	0.55	0.28	=	3.47	1.12	0.15	=	1.62	0.68	0.15	=	0.22	0.21	0.35	U	1.83	0.52	0.56	=
SLD95131	SLD95132	907176	1030943	0.13	0.23	0.33	UJ	0.37	0.62	0.95	UJ	4.97	1.16	0.09	=	1.25	0.08	0.12	=	0.94	0.44	0.22	=	3.12	0.93	0.26	=	1.46	0.57	0.12	=	0.31	0.26	0.44	U	3.08	0.76	0.66	=
SLD95133	SLD95133	907165	1030867	0.04	0.23	0.32	UJ	-0.16	0.56	0.83	UJ	3.12	0.75	0.08	=	1.14	0.09	0.11	=	1.08	0.55	0.46	J	3.52	1.13	0.28	=	1.38	0.62	0.15	=	0.11	0.25	0.42	UJ	3.74	0.76	0.60	=
SLD95135	SLD95135	907236	1030896	0.00	0.19	0.31	UJ	0.04	0.56	0.85	UJ	2.12	0.52	0.07	=	1.04	0.08	0.10	=	1.30	0.56	0.13	=	1.88	0.70	0.13	=	1.21	0.53	0.13	=	0.16	0.24	0.41	UJ	2.48	0.62	0.56	=
SLD95135	SLD95136	907236	1030896	0.01	0.19	0.30	UJ	0.62	0.69	0.84	UJ	2.18	0.53	0.08	=	0.96	0.08	0.11	=	1.08	0.52	0.36	=	2.11	0.76	0.25	=	1.08	0.51	0.13	=	0.07	0.24	0.39	UJ	1.93	0.65	0.58	=
SLD95135	SLD95137	907236	1030896	0.17	0.21	0.32	UJ	0.33	0.58	0.90	UJ	3.49	0.83	0.08	=	1.14	0.08	0.11	=	1.72	0.72	0.58	=	2.63	0.91	0.14	=	0.79	0.44	0.14	J	0.14	0.26	0.43	UJ	2.82	0.61	0.63	=
SLD95135	SLD95138	907236	1030896	0.16	0.16	0.27	UJ	0.38	0.48	0.77	UJ	1.33	0.34	0.07	=	1.24	0.09	0.11	=	1.12	0.50	0.30	=	1.56	0.60	0.12	=	1.25	0.52	0.12	=	0.02	0.21	0.35	UJ	1.71	0.61	0.54	=
SLD95139	SLD95139	907154	1030792	0.08	0.12	0.21	UJ	-0.16	0.36	0.52	UJ	1.54	0.38	0.05	=	0.51	0.05	0.07	=	0.32	0.26	0.24	J	1.60	0.63	0.24	J	0.84	0.43	0.24	J	-0.07	0.15	0.24	UJ	1.34	0.45	0.36	J
SLD95139	SLD95140	907154	1030792	-0.09	0.17	0.27	UJ	0.60	0.45	0.81	U	1.21	0.31	0.07	=	1.20	0.09	0.11	=	1.29	0.58	0.26	=	1.14	0.54	0.26	J	1.41	0.61	0.14	=	0.07	0.21	0.35	UJ	1.36	0.60	0.53	J
SLD95141	SLD95141	907225	1030820	-0.07	0.12	0.18	UJ	-0.09	0.35	0.51	UJ	1.45	0.35	0.05	=	0.60	0.05	0.07	=	0.69	0.41	0.14	J	1.93	0.75	0.32	=	0.79	0.44	0.14	J	-0.08	0.15	0.24	UJ	1.28	0.41	0.37	=
SLD95141	SLD95142	907225	1030820	-0.04	0.20	0.29	UJ	-0.24	0.52	0.76	UJ	3.47	0.82	0.07	=	0.96	0.07	0.10	=	1.18	0.57	0.15	=	2.64	0.94	0.15	=	1.22	0.58	0.28	=	0.15	0.23	0.38	UJ	2.31	0.65	0.56	=
SLD95143	SLD95143	907073	1030688	0.16	0.20	0.31	UJ	0.05	0.58	0.82	UJ	5.49	1.26	0.07	=	1.17	0.07	0.09	=	1.47	0.64	0.15	=	4.46	1.33	0.28	=	1.23	0.58	0.33	=	0.43	0.24	0.41	J	4.74	0.79	0.65	=
SLD95143	SLD95144	907073	1030688	-0.07	0.14	0.20	UJ	0.11	0.36	0.52	UJ	1.98	0.47	0.05	=	0.38	0.04	0.06	=	0.38	0.29	0.25	J	2.54	0.86	0.30	=	0.54	0.34	0.13	J	0.02	0.16	0.27	UJ	1.48	0.43	0.41	J
SLD95145	SLD95145	907144	1030716	0.16	0.15	0.23	U	0.30	0.43	0.63	UJ	2.76	0.64	0.05	=	0.75	0.05	0.06	=	0.65	0.38	0.24	J	2.79	0.90	0.13	=	1.03	0.49	0.24	=	0.26	0.26	0.32	U	2.18	0.38	0.50	=
SLD95145	SLD95145-1	907144	1030716	0.17	0.13	0.22	U	0.24	0.42	0.61	UJ	2.86	0.67	0.05	=	0.75	0.05	0.06	=	0.86	0.41	0.11	=	1.76	0.63	0.33	J	0.48	0.30	0.21	J	0.25	0.22	0.31	U	1.79	0.49	0.50	=
SLD95145	SLD95146	907144	1030716	0.06	0.14	0.23	UJ	0.10	0.43	0.61	UJ	1.40	0.35	0.06	=	1.17	0.06	0.07	=	1.19	0.53	0.24	=	1.50	0.61	0.13	J	1.35	0.57	0.13	=	0.03	0.19	0.31	UJ	1.00	0.55	0.51	J
SLD95145	SLD95147	907144	1030716	0.17	0.20	0.26	UJ	0.05	0.49	0.70	UJ	1.12	0.29	0.07	=	1.21	0.07	0.09	=	1.10	0.49	0.12	=	1.98	0.70	0.22	=	0.78	0.40	0.22	J	0.22	0.20	0.35	U	1.05	0.58	0.59	J
SLD95145	SLD95148	907144	1030716	-0.10	0.16	0.25	UJ	0.06	0.52	0.73	UJ	1.34	0.34	0.06	=	1.22	0.07	0.09	=	1.03	0.49	0.24	=	1.42	0.58	0.13	J	1.47	0.60	0.13	=	0.10	0.21	0.36	UJ	1.18	0.71	0.60	J
SLD95149	SLD95149	907062	1030612	0.10	0.09	0.16	U	0.07	0.29	0.41	UJ	1.14	0.28	0.04	=	0.38	0.03	0.04	=	0.61	0.37	0.14	J	1.17	0.54	0.14	J	0.66	0.39	0.14	J	0.03	0.12	0.19	UJ	0.75	0.37	0.34	J
SLD95149	SLD95150	907062	1030612	0.06	0.15	0.26	UJ	0.24	0.45	0.68	UJ	3.98	0.92	0.06	=	0.86	0.06	0.09	=	1.13	0.51	0.24	=	2.99	0.94	0.13	=	0.78	0.42	0.29	J	0.10	0.20	0.33	UJ	3.03	0.51	0.46	=
SLD95151	SLD95151	907334	1030650	0.06	0.15	0.24	UJ	0.42	0.47	0.68	UJ	1.45	0.37	0.06	=	0.71	0.06	0.07	=	0.93	0.49	0.32	J	1.21	0.57	0.27	J	0.69	0.41	0.14	J	0.04	0.19	0.31	UJ	0.92	0.43	0.47	J
SLD95151	SLD95151-1	907334	1030650	-0.17	0.13	0.19	UJ	0.27	0.35	0.57	UJ	1.38	0.34	0.05	=	0.57	0.05	0.06	=	0.84	0.46	0.27	J	1.54	0.65	0.27	J	0.80	0.44	0.15	J	0.08	0.16	0.27	UJ	1.34	0.52	0.44	J
SLD95151	SLD95152	907334	1030650	-0.01	0.23	0.34	UJ	-0.11	0.66	0.96	UJ	5.02	1.16	0.09	=	0.95	0.07	0.12	=	1.28	0.65	0.18	J	4.03	1.36	0.34	=	1.38	0.69	0.40	=	0.25	0.26	0.44	UJ	4.01	0.70	0.64	=
SLD95151	SLD95153	907334	1030650	-0.07	0.16	0.26	UJ	0.06	0.48	0.73	UJ	1.18	0.31	0.07	=	1.15	0.08	0.10	=	1.93	0.77	0.29	=	2.14	0.83	0.34	J	1.48	0.66	0.15	=	0.12	0.21	0.35	UJ	1.56	0.54	0.53	J
SLD95151	SLD95154	907334	1030650	0.18	0.26	0.45	UJ	0.72	0.80	1.29	UJ	1.04	0.31	0.12	=	1.27	0.12	0.16	=	1.66	0.65	0.13	=	2.00	0.73	0.13	J	1.51	0.62	0.13	=	0.17	0.33	0.56	UJ	0.88	0.93	1.63	UJ
SLD95317	SLD95317	907124	1030728	0.08	0.14	0.21	UJ	0.19	0.39	0.57	UJ	2.27	0.54	0.05	=	0.87	0.05	0.07	=	1.21	0.53	0.24	=	2.28	0.79	0.28	=	0.94	0.46	0.13	=	0.12	0.18	0.30	UJ	1.97	0.51	0.49	=
SLD95317	SLD95318	907124	1030728	0.04	0.13	0.19	UJ	0.36	0.32	0.53	U	0.96	0.24	0.04	=	0.80	0.05	0.07	=	1.20	0.54	0.29	=	2.24	0.79	0.25	=	0.93	0.46	0.13	=	0.21	0.15	0.26	U	0.89	0.37	0.42	J
SLD95319	SLD95319	907298	1030773	0.29	0.19	0.30	U	0.27	0.70	0.80	UJ	3.76	0.88	0.08	=	0.98	0.07	0.09	=	1.19	0.56	0.26	=	2.94	0.97	0.14	=	0.93	0.48	0.26	J	0.35	0.22	0.40	U	2.34	0.70	0.65	=
SLD95319	SLD95320	907298	1030773	-0.02	0.43	0.68	UJ	0.59	1.18	1.75	UJ	4.49	1.12	0.18	=	1.12	0.16	0.21	=	1.12	0.50	0.12	=	2.96	0.91	0.23	=	1.21	0.52	0.12	=	0.17	0.51	0.85	UJ	3.02	1.42	1.37	J

Notes:

Results are expressed in pCi/g.

Values reported to two decimal places regardless of the number of significant digits.

Validation qualifiers (VQs) 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.

Table C-2. DT-36 Final Status Survey Soil Sample Data

Station Name	Sample Name	Easting	Northing	Ac-227				Pa-231				Ra-226				Ra-228				Th-228				Th-230				Th-232				U-235				U-238			
				Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ	Result	Error	MDC	VQ
SLD95212	SLD95212	906839	1030742	-0.07	0.11	0.18	UJ	0.05	0.37	0.54	UJ	1.19	0.30	0.05	=	0.65	0.05	0.07	=	0.96	0.49	0.26	J	1.44	0.61	0.14	=	1.08	0.52	0.14	=	0.12	0.15	0.24	UJ	0.88	0.42	0.36	J
	SLD95213	906839	1030742	-0.07	0.15	0.23	UJ	0.16	0.41	0.62	UJ	1.20	0.31	0.06	=	0.77	0.06	0.09	=	1.10	0.55	0.16	J	2.13	0.83	0.29	=	1.33	0.62	0.16	=	0.09	0.17	0.29	UJ	0.85	0.51	0.45	J
SLD95301	SLD95301	906770	1030855	0.05	0.12	0.19	UJ	0.16	0.34	0.52	UJ	1.51	0.37	0.05	=	0.54	0.04	0.07	=	1.05	0.51	0.14	J	2.09	0.78	0.27	=	0.66	0.40	0.32	J	0.05	0.15	0.24	UJ	1.40	0.41	0.34	J
	SLD95302	906770	1030855	-0.06	0.17	0.26	UJ	0.54	0.50	0.80	U	1.29	0.34	0.08	=	1.14	0.08	0.09	=	1.34	0.59	0.14	J	1.68	0.68	0.26	=	1.08	0.52	0.14	=	0.00	0.22	0.35	UJ	0.97	0.50	0.56	J
	SLD95303	906770	1030855	0.11	0.14	0.25	UJ	0.24	0.46	0.70	UJ	1.20	0.31	0.06	=	0.98	0.07	0.09	=	1.16	0.52	0.24	J	1.45	0.59	0.13	=	1.49	0.60	0.13	=	0.02	0.19	0.31	UJ	1.29	0.48	0.45	J
	SLD95304	906770	1030855	0.00	0.19	0.30	UJ	-0.27	0.56	0.81	UJ	1.39	0.37	0.08	=	1.21	0.09	0.09	=	1.42	0.56	0.22	J	1.34	0.54	0.22	=	0.91	0.43	0.12	=	0.10	0.24	0.39	UJ	1.18	0.76	0.58	J
SLD95305	SLD95305	906843	1030788	-0.11	0.12	0.19	UJ	-0.15	0.38	0.54	UJ	1.17	0.29	0.05	=	0.74	0.05	0.07	=	1.36	0.64	0.30	J	2.04	0.82	0.16	=	1.32	0.62	0.16	=	0.19	0.18	0.25	U	0.89	0.39	0.38	J
	SLD95306	906843	1030788	-0.09	0.16	0.24	UJ	0.33	0.46	0.71	UJ	1.39	0.35	0.06	=	1.09	0.08	0.09	=	1.47	0.66	0.16	J	2.04	0.81	0.30	=	1.70	0.72	0.16	=	-0.04	0.19	0.31	UJ	0.56	0.52	0.52	J
	SLD95307	906843	1030788	-0.05	0.32	0.54	UJ	0.02	1.07	1.57	UJ	0.98	0.33	0.16	J	1.18	0.15	0.20	=	1.86	0.75	0.33	J	1.82	0.74	0.28	=	1.33	0.61	0.15	=	0.04	0.41	0.67	UJ	0.73	0.77	1.31	UJ
	SLD95307-1	906843	1030788	0.07	0.18	0.30	UJ	0.52	0.57	0.91	UJ	1.09	0.30	0.08	=	1.20	0.09	0.11	=	1.63	0.62	0.22	J	1.51	0.59	0.12	=	1.04	0.48	0.27	=	-0.14	0.21	0.34	UJ	1.42	0.70	0.58	J
	SLD95308	906843	1030788	0.09	0.14	0.24	UJ	-0.20	0.42	0.60	UJ	1.15	0.29	0.06	=	1.02	0.06	0.08	=	1.29	0.55	0.13	J	1.56	0.62	0.24	=	1.67	0.65	0.13	=	-0.09	0.17	0.27	UJ	0.95	0.37	0.43	J
SLD95309	SLD95309	906843	1030650	-0.08	0.14	0.21	UJ	-0.17	0.41	0.59	UJ	1.13	0.29	0.06	=	0.75	0.05	0.07	=	0.87	0.44	0.13	J	1.59	0.63	0.24	=	0.87	0.44	0.13	J	-0.06	0.17	0.27	UJ	1.43	0.51	0.41	J
	SLD95310	906843	1030650	0.02	0.13	0.22	UJ	-0.03	0.39	0.56	UJ	1.16	0.29	0.06	=	0.93	0.06	0.08	=	0.96	0.49	0.14	J	1.14	0.55	0.32	=	0.85	0.46	0.14	J	0.34	0.25	0.29	UJ	0.93	0.45	0.44	J
	SLD95311	906843	1030650	-0.01	0.15	0.24	UJ	-0.15	0.46	0.68	UJ	1.18	0.31	0.07	=	0.95	0.07	0.09	=	1.15	0.54	0.14	J	1.39	0.61	0.31	=	0.58	0.37	0.14	J	0.02	0.19	0.31	UJ	0.85	0.50	0.52	J
	SLD95312	906843	1030650	0.10	0.14	0.25	UJ	0.08	0.45	0.67	UJ	1.19	0.31	0.06	=	1.25	0.07	0.09	=	1.25	0.52	0.22	J	2.00	0.69	0.12	=	1.21	0.51	0.12	=	0.07	0.18	0.30	UJ	1.11	0.53	0.47	J
SLD95313	SLD95313	906848	1030687	0.13	0.14	0.20	UJ	0.14	0.32	0.49	UJ	1.48	0.36	0.05	=	0.47	0.04	0.06	=	0.61	0.37	0.24	J	1.20	0.53	0.13	=	0.37	0.28	0.24	J	-0.01	0.15	0.24	UJ	1.25	0.41	0.40	J
	SLD95314	906848	1030687	0.00	0.14	0.22	UJ	0.35	0.41	0.61	UJ	1.19	0.30	0.06	=	0.92	0.06	0.07	=	1.04	0.46	0.21	=	1.13	0.48	0.11	=	1.21	0.50	0.11	=	-0.02	0.18	0.29	UJ	0.92	0.34	0.47	J
SLD95315	SLD95315	906825	1030790	-0.04	0.12	0.19	UJ	-0.23	0.39	0.52	UJ	1.20	0.30	0.05	=	0.71	0.05	0.07	=	0.83	0.45	0.27	J	1.62	0.67	0.27	=	0.95	0.48	0.14	J	0.03	0.16	0.26	UJ	1.05	0.32	0.43	J
	SLD95316	906825	1030790	0.00	0.12	0.20	UJ	-0.19	0.42	0.56	UJ	1.16	0.29	0.05	=	0.80	0.05	0.06	=	0.82	0.42	0.23	J	1.79	0.67	0.13	=	0.60	0.35	0.12	J	0.03	0.16	0.26	UJ	0.94	0.52	0.46	J
SLD95464	SLD95464	906864	1030600	0.00	0.12	0.21	UJ	-0.20	0.42	0.60	UJ	1.15	0.29	0.06	=	0.93	0.06	0.08	=	1.96	0.77	0.28	=	1.18	0.57	0.33	J	1.37	0.61	0.15	=	0.15	0.16	0.27	UJ	0.94	0.41	0.41	=
	SLD95465	906864	1030600	0.02	0.16	0.26	UJ	0.78	0.59	0.83	U	1.11	0.29	0.07	=	1.03	0.07	0.09	=	2.19	0.78	0.13	=	1.50	0.61	0.25	J	1.59	0.64	0.25	=	-0.02	0.20	0.32	UJ	0.72	0.50	0.46	J

Notes:

Results are expressed in pCi/g.

Values reported to two decimal places regardless of the number of significant digits.

Validation qualifiers (VQs) are defined as follows:

"=" - Positive result.

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

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"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.

APPENDIX D

EVALUATION OF FINAL STATUS SURVEY SOIL SAMPLE DATA

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

Number of Systematic Samples:	11		Number of Biased Samples:	9		Area:	5,299 m^2

Statistic	Type	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	SOR_G	SOR_N
Mean	Systematic	0.05	0.11	2.28	0.80	0.94	2.45	1.01	0.14	2.28	0.51	0.12
Median	Systematic	0.04	0.05	2.06	0.78	1.00	1.93	1.03	0.11	1.83	0.40	0.04
Standard Deviation	Systematic	0.07	0.25	1.24	0.26	0.34	1.09	0.34	0.17	1.42	0.37	0.19
Maximum	All	0.30	0.66	5.69	1.23	1.68	6.22	1.62	0.43	4.74	1.57	0.94
Range	All	0.30	0.66	4.56	0.85	1.36	5.05	1.11	0.43	3.99	1.43	0.94

Sample/ Station Name	GWS-Based Area (m^2)	Type	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	SOR_G	SOR_N
HTZ94765	1	Biased	0.30	0.17	5.69	1.15	1.68	6.22	1.27	0.38	3.53	1.57	0.94
HTZ94766[a]	1	Biased	-0.15	0.60	1.29	1.23	1.06	1.63	1.51	0.18	3.02	0.27	0.06
HTZ94767	1	Biased	0.06	0.09	1.43	0.57	0.98	3.68	0.60	-0.13	2.04	0.90	0.36
HTZ94784	1	Biased	-0.05	0.06	1.13	0.77	1.27	1.28	0.82	0.00	0.94	0.44	0.00
HTZ94785[b]	--	Biased	0.12	0.09	3.90	0.67	1.18	4.91	1.02	0.06	2.56	1.24	0.62
HTZ94786[b]	--	Biased	0.07	0.10	3.53	0.68	0.68	3.46	1.12	0.18	3.17	0.99	0.34
HTZ94787[b]	--	Biased	0.26	0.34	3.98	0.80	1.32	3.75	1.09	0.25	3.27	1.08	0.40
SLD95125[a]	--	Systematic	-0.02	0.06	1.41	0.78	1.00	1.73	0.51	0.11	1.34	0.19	0.00
SLD95127[a]	--	Systematic	0.04	0.01	2.06	0.80	1.20	3.17	1.09	0.39	4.47	0.37	0.14
SLD95131[a]	--	Systematic	0.00	0.66	2.52	0.97	1.11	3.47	1.62	0.22	1.83	0.38	0.14
SLD95133[a]	--	Systematic	0.04	-0.16	3.12	1.14	1.08	3.52	1.38	0.11	3.74	0.40	0.17
SLD95135	--	Systematic	0.00	0.04	2.12	1.04	1.30	1.88	1.21	0.16	2.48	0.72	0.04
SLD95139[a]	--	Systematic	0.08	-0.16	1.54	0.51	0.32	1.60	0.84	-0.07	1.34	0.19	0.00
SLD95141	--	Systematic	-0.07	-0.09	1.45	0.60	0.69	1.93	0.79	-0.08	1.28	0.57	0.00
SLD95143	--	Systematic	0.16	0.05	5.49	1.17	1.47	4.46	1.23	0.43	4.74	1.44	0.65
SLD95145	--	Systematic	0.16	0.30	2.76	0.75	0.65	2.79	1.03	0.26	2.18	0.81	0.18
SLD95149[a]	--	Systematic	0.10	0.07	1.14	0.38	0.61	1.17	0.66	0.03	0.75	0.14	0.00
SLD95151	--	Systematic	0.06	0.42	1.45	0.71	0.93	1.21	0.69	0.04	0.92	0.45	0.00
SLD95317	--	Biased	0.08	0.19	2.27	0.87	1.21	2.28	0.94	0.12	1.97	0.68	0.08
SLD95319	--	Biased	0.29	0.27	3.76	0.98	1.19	2.94	0.93	0.35	2.34	0.99	0.22

[a] Sample was collected under cover materal greater than 0.5 ft thick, used subsurface SOR calculations.

[b] Samples were collected to investigate sample HTZ94765.

Notes:

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

Negative results are less than the laboratory system's background level.

Values reported to two decimal places regardless of the number of significant digits.

Table D-2. SU-1 Subsurface Soil Data Summary

Number of Subsurface Samples:	20

Statistic	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	SOR_G	SOR_N
Mean	0.02	0.24	2.33	1.04	1.21	2.26	1.14	0.12	1.93	0.29	0.06
Median	0.01	0.21	1.82	1.13	1.16	2.13	1.22	0.12	1.71	0.25	0.03
Standard Deviation	0.11	0.26	1.38	0.22	0.33	0.69	0.31	0.09	0.87	0.10	0.06
Maximum	0.18	0.72	5.02	1.27	1.93	4.03	1.51	0.31	4.01	0.51	0.22
Range	0.18	0.72	4.06	0.89	1.55	2.89	0.97	0.31	3.13	0.31	0.21

Sample Name	Station Name	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	SOR_G	SOR_N
SLD95126	SLD95125	0.05	0.03	1.99	0.76	1.10	2.60	0.67	0.21	1.50	0.25	0.05
SLD95128	SLD95127	-0.01	0.31	2.52	0.93	0.91	1.92	1.01	0.12	2.15	0.28	0.01
SLD95129	SLD95127	-0.21	0.19	1.66	1.04	1.49	2.07	0.97	-0.08	1.88	0.24	0.02
SLD95130	SLD95127	0.02	-0.02	1.36	1.13	1.37	1.66	1.42	0.04	1.70	0.24	0.03
SLD95132	SLD95131	0.13	0.37	4.97	1.25	0.94	3.12	1.46	0.31	3.08	0.49	0.20
SLD95136	SLD95135	0.01	0.62	2.18	0.96	1.08	2.11	1.08	0.07	1.93	0.26	0.02
SLD95137	SLD95135	0.17	0.33	3.49	1.14	1.72	2.63	0.79	0.14	2.82	0.37	0.09
SLD95138	SLD95135	0.16	0.38	1.33	1.24	1.12	1.56	1.25	0.02	1.71	0.22	0.03
SLD95140	SLD95139	-0.09	0.60	1.21	1.20	1.29	1.14	1.41	0.07	1.36	0.20	0.02
SLD95142	SLD95141	-0.04	-0.24	3.47	0.96	1.18	2.64	1.22	0.15	2.31	0.36	0.07
SLD95144	SLD95143	-0.07	0.11	1.98	0.38	0.38	2.54	0.54	0.02	1.48	0.24	0.04
SLD95146	SLD95145	0.06	0.10	1.40	1.17	1.19	1.50	1.35	0.03	1.00	0.21	0.02
SLD95147	SLD95145	0.17	0.05	1.12	1.21	1.10	1.98	0.78	0.22	1.05	0.23	0.02
SLD95148	SLD95145	-0.10	0.06	1.34	1.22	1.03	1.42	1.47	0.10	1.18	0.22	0.03
SLD95150	SLD95149	0.06	0.24	3.98	0.86	1.13	2.99	0.78	0.10	3.03	0.38	0.11
SLD95152	SLD95151	-0.01	-0.11	5.02	0.95	1.28	4.03	1.38	0.25	4.01	0.51	0.22
SLD95153	SLD95151	-0.07	0.06	1.18	1.15	1.93	2.14	1.48	0.12	1.56	0.27	0.04
SLD95154	SLD95151	0.18	0.72	1.04	1.27	1.66	2.00	1.51	0.17	0.88	0.25	0.03
SLD95318	SLD95317	0.04	0.36	0.96	0.80	1.20	2.24	0.93	0.21	0.89	0.23	0.02
SLD95320	SLD95319	-0.02	0.59	4.49	1.12	1.12	2.96	1.21	0.17	3.02	0.44	0.16

Notes:

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

Negative results are less than the laboratory system's background level.

Values reported to two decimal places regardless of the number of significant digits.

Table D-3. Class 3 SU-2 Random and Biased Soil Data Summary

Number of Random Samples:	6		Number of Biased Samples:	1		Area:	3,665 m^2

Statistic	Type	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	SOR_G	SOR_N
Mean	Random	-0.02	-0.03	1.28	0.64	0.95	1.66	0.87	0.05	1.15	0.20	0.01
Median	Random	-0.05	-0.05	1.20	0.68	0.92	1.61	0.91	0.04	1.15	0.19	0.00
Standard Deviation	Random	0.09	0.17	0.17	0.12	0.25	0.35	0.33	0.09	0.25	0.03	0.01
Maximum	All	0.13	0.16	1.51	0.93	1.96	2.09	1.37	0.19	1.43	0.24	0.02
Range	All	0.13	0.16	0.38	0.46	1.35	0.91	1.00	0.19	0.55	0.09	0.02

Sample/ Station Name	GWS-Based Area (m^2)	Type	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	SOR_G	SOR_N
SLD95212	--	Random	-0.07	0.05	1.19	0.65	0.96	1.44	1.08	0.12	0.88	0.19	0.00
SLD95301	--	Random	0.05	0.16	1.51	0.54	1.05	2.09	0.66	0.05	1.40	0.21	0.01
SLD95305	--	Random	-0.11	-0.15	1.17	0.74	1.36	2.04	1.32	0.19	0.89	0.24	0.02
SLD95309	--	Random	-0.08	-0.17	1.13	0.75	0.87	1.59	0.87	-0.06	1.43	0.19	0.00
SLD95313	--	Random	0.13	0.14	1.48	0.47	0.61	1.20	0.37	-0.01	1.25	0.15	0.00
SLD95315	--	Random	-0.04	-0.23	1.20	0.71	0.83	1.62	0.95	0.03	1.05	0.19	0.00
SLD95464	--	Biased	0.00	-0.20	1.15	0.93	1.96	1.18	1.37	0.15	0.94	0.19	0.02

Notes:

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

Negative results are less than the laboratory system's background level.

All samples were collected under cover materal greater than 0.5 ft thick, used subsurface SOR calculations.

Values reported to two decimal places regardless of the number of significant digits.

Table D-4. SU-2 Subsurface Soil Data Summary

Number of Subsurface Samples:	13

Statistic	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	SOR_G	SOR_N
Mean	0.01	0.13	1.20	1.02	1.31	1.61	1.20	0.04	0.92	0.21	0.02
Median	0.00	0.08	1.19	1.02	1.25	1.56	1.21	0.02	0.93	0.22	0.02
Standard Deviation	0.06	0.31	0.11	0.15	0.37	0.33	0.38	0.10	0.20	0.03	0.02
Maximum	0.11	0.78	1.39	1.25	2.19	2.13	1.70	0.34	1.29	0.26	0.05
Range	0.11	0.78	0.41	0.49	1.38	1.00	1.13	0.34	0.73	0.10	0.05

Sample Name	Station Name	Ac-227	Pa-231	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-235	U-238	SOR_G	SOR_N
SLD95213	SLD95212	-0.07	0.16	1.20	0.77	1.10	2.13	1.33	0.09	0.85	0.25	0.03
SLD95302	SLD95301	-0.06	0.54	1.29	1.14	1.34	1.68	1.08	0.00	0.97	0.21	0.01
SLD95303	SLD95301	0.11	0.24	1.20	0.98	1.16	1.45	1.49	0.02	1.29	0.22	0.03
SLD95304	SLD95301	0.00	-0.27	1.39	1.21	1.42	1.34	0.91	0.10	1.18	0.20	0.02
SLD95306	SLD95305	-0.09	0.33	1.39	1.09	1.47	2.04	1.70	-0.04	0.56	0.26	0.05
SLD95307	SLD95305	-0.05	0.02	0.98	1.18	1.86	1.82	1.33	0.04	0.73	0.22	0.02
SLD95308	SLD95305	0.09	-0.20	1.15	1.02	1.29	1.56	1.67	-0.09	0.95	0.23	0.04
SLD95310	SLD95309	0.02	-0.03	1.16	0.93	0.96	1.14	0.85	0.34	0.93	0.16	0.00
SLD95311	SLD95309	-0.01	-0.15	1.18	0.95	1.15	1.39	0.58	0.02	0.85	0.17	0.00
SLD95312	SLD95309	0.10	0.08	1.19	1.25	1.25	2.00	1.21	0.07	1.11	0.24	0.02
SLD95314	SLD95313	0.00	0.35	1.19	0.92	1.04	1.13	1.21	-0.02	0.92	0.18	0.01
SLD95316	SLD95315	0.00	-0.19	1.16	0.80	0.82	1.79	0.60	0.03	0.94	0.19	0.00
SLD95465	SLD95464	0.02	0.78	1.11	1.03	2.19	1.50	1.59	-0.02	0.72	0.22	0.03

Notes:

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

Negative results are less than the laboratory system's background level

Values reported to two decimal places regardless of the number of significant digits.

APPENDIX E

DETERMINATION OF THE MINIMUM NUMBER OF SYSTEMATIC OR RANDOM SAMPLES

DETERMINATION OF THE MINIMUM NUMBER OF SYSTEMATIC OR RANDOM SAMPLES

The number of systematic or random samples for the subject properties was based on experience with other properties. The following retrospective analysis confirmed that an adequate number of systematic or random samples were collected.

To meet the minimum statistical requirements (i.e., WRS test) for each soil SU, MARSSIM provides guidance on determining the minimum number of samples. The necessary parameters for calculating the minimum number of samples and their values are:

- Type I error probability (probability of a false decision that the radionuclide RGs are met when they are actually not met)—set at 0.05 per the FSSP.
- Type II error probability (probability of a false decision that the radionuclide RGs are not met when they actually are met)—typically set at 0.20. FSSP allowed values are 0.05 to 0.25.
- DCGL—set at $SOR_N = 1.0$ per the SLDS ROD.
- Variability of the contaminant concentration (i.e., standard deviation [σ])—set based upon engineering estimates for the SU per MARSSIM. Examples include calculating the effective σ (σ_{eff}) for multiple radionuclides using characterization or screening sample results from the SU, and using a historical effective σ based on samples taken previously from other SUs within the SLDS Sites.
- Lower bound of the gray region (LBGR)—set based upon engineering estimates for the SU per MARSSIM. Examples include using the mean SOR_N calculated from characterization or screening samples in the SU, and using half of the DCGL as an arbitrary, but reasonable, starting point per MARSSIM. The LBGR is the SOR_N value at which the Type II error is specified, and is adjustable to achieve the desired relative shift (Δ/σ_{eff}) between 1 and 3, with up to 4 being acceptable.

Of these five parameters, only the last two typically vary from SU to SU. For SU-1, the values were based on the realistic upper bound of what the parameters would be. The realistic upper bound values were from data that was obtained during evaluations of other SUs within the SLDS. Realistic upper bound values were chosen since they will yield more samples than lower values would. The realistic upper bound values for the mean and effective standard deviation of the SOR_N were 0.50 and 0.35, respectively. Using these values resulted in 11 systematic samples.

For SU-2, data from sampling an adjacent similar property were used to determine the mean and standard deviation of the SOR_N of 0.25 and 0.20, respectively. Using these values resulted in six random samples.

Once the property-specific FSS data was 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 LBGR at the mean SOR_N concentration when reviewing the SU retrospectively.

The σ_{eff} was calculated for SU-1 using SOR_G results from the systematic FSS samples. The specific σ values for SU-1 in pCi/g are as follows: 1.24 for Ra-226, 1.09 for Th-230, 0.34 for Th-232, and 1.42 for U-238. Using these values, the σ_{eff} was calculated:

$$\sigma_{eff} = \sqrt{\left(\frac{\sigma_{Ra-226}}{DCGL_{Ra-226}}\right)^2 + \left(\frac{\sigma_{Th-230}}{DCGL_{Th-230}}\right)^2 + \left(\frac{\sigma_{Th-232}}{DCGL_{Th-232}}\right)^2 + \left(\frac{\sigma_{U-238}}{DCGL_{U-238}}\right)^2} = \sqrt{\left(\frac{1.24}{5}\right)^2 + \left(\frac{1.09}{5}\right)^2 + \left(\frac{0.34}{5}\right)^2 + \left(\frac{1.42}{50}\right)^2} = 0.34$$

The next step was to calculate the relative shift. The LBGR was set to the SU SOR_N mean value (0.18). (Note: This SOR_N mean value was developed using surface criteria for all systematic samples. The SOR_N mean value presented in Appendix E Table E-1 was of sample SOR_N where both surface and subsurface criteria where applied as appropriate because of cover material.)

$$\frac{\Delta}{\sigma_{eff}} = \frac{DCGL - LBGR}{\sigma_{eff}} = \frac{1.0 - 0.18}{0.34} = 2.4$$

Using Equation 5.1 in MARSSIM, the minimum number of systematic samples for SU-1 was seven.

For SU- 2, a similar calculation was performed with standard deviations of 0.17 for Ra-226, 0.35 for Th-230, 0.33 for Th-232, and 0.25 for U-238. Using these values the σ_{eff} was calculated as shown below.

$$\sigma_{eff} = \sqrt{\left(\frac{\sigma_{Ra-226}}{DCGL_{Ra-226}}\right)^2 + \left(\frac{\sigma_{Th-230}}{DCGL_{Th-230}}\right)^2 + \left(\frac{\sigma_{Th-232}}{DCGL_{Th-232}}\right)^2 + \left(\frac{\sigma_{U-238}}{DCGL_{U-238}}\right)^2} = \sqrt{\left(\frac{0.17}{5}\right)^2 + \left(\frac{0.35}{5}\right)^2 + \left(\frac{0.33}{5}\right)^2 + \left(\frac{0.25}{50}\right)^2} = 0.03$$

With 0.01 for the LBGR, the relative shift was 33. Per MARSSIM, the retrospective use of actual SU data does not require adjustment to get the relative shift between one and four. Using Equation 5.1 in MARSSIM, the minimum number of random surfacc samples for SU-2 was five.

Table E-1 lists the calculated minimum number of systematic or random sample and the actual number of FSS samples collected in each SU. A sufficient number of samples were collected from each SU.

Table E-1. Number of Systematic or Random Samples

SU	Class	Minimum Number of Samples per MARSSIM	Number of Systematic/Random Samples Collected
SU-1	2	7	11
SU-2	3	5	6

APPENDIX F

QUALITY CONTROL SUMMARY REPORT

(On the CDROM on the Back Cover of this Report)

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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

Final status survey sampling was conducted for the SLDS properties DT-35 and DT-36. Sampling was conducted in accordance with MARSSIM and the FSSP.

1.2 PROJECT OBJECTIVES

The intent of the QCSR is to document the usability of the data based on project DQOs, precision, accuracy, representativeness, comparability, completeness, and sensitivity.

1.3 PROJECT IMPLEMENTATION

The sampling was conducted from June 2006 until July 2006. Radiological analyses were onsite FUSRAP laboratory at the Hazelwood Interim Storage Site (HISS) with QA split samples being analyzed by Test America (formerly, Severn-Trent Laboratories).

1.4 PURPOSE OF THIS REPORT

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

2.0 QUALITY ASSURANCE PROGRAM

A Quality Assurance Project Plan (QAPP) was developed for this project and is part of the SAG for the St. Louis Sites. The QAPP established requirements for both field and laboratory QC procedures. An analytical laboratory QC duplicate sample, laboratory control sample (LCS), and a method blank were required for every 20 field samples of each matrix.

A primary goal of the QA program was to ensure that the quality of measurements was appropriate for the intended use of the results. 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.

The resulting "definitive" data, as defined by EPA, has been reported including the following basic information:

- Laboratory case narratives
- Sample results
- Laboratory method blank results
- Laboratory control standard results
- Laboratory duplicate sample results
- Tracer recoveries
- Sample extraction dates
- Sample analysis dates

This information provides the basis for an independent data evaluation relative to accuracy, precision, sensitivity, representativeness, comparability, and completeness, as discussed in the following sections.

3.0 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 have been retained with laboratory data deliverables by SAIC.

3.1 LABORATORY DATA VALIDATION

Analytical data generated for this project have been subjected to a process of data verification, validation, and review. The SAG and the following documents establish the criteria against which the data are compared and from which a judgment is rendered regarding the acceptance and qualification of the data:

- *Department of Defense Quality Systems Manual for Environmental Laboratories* (QSM) (DOD 2006).
- *USACE Kansas City and St. Louis District Radionuclide Data Quality Evaluation Guidance for Alpha and Gamma Spectroscopy* (USACE 2002b).
- *Data Validation* (SAIC 2006).

Upon receipt of field and analytical data, verification staff performed a systematic examination of the reports to ensure the content, presentation, and administrative validity of the data. In conjunction with data package verification, laboratory electronic data deliverables were available. These data 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 provided in the above referenced documents. 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:

- Holding time information and methods requested
- Discussion of laboratory analysis, including any laboratory problems
- Sample results
- Initial calibration
- Efficiency check
- Background determinations
- Spike recovery results
- Internal standard results (tracers or carriers)
- Duplicate sample results
- Self-absorption factor (for alpha and beta radioactivity)
- Cross-talk factor (during simultaneous detection of alpha and beta radioactivity)
- Laboratory control samples
- 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 with a reason code to explain the retention or the qualifier.

3.2 DEFINITION OF DATA QUALIFIERS (FLAGS)

During the data validation process, all laboratory data were assigned appropriate data validation qualifiers (VQs) and reason codes, as follows:

"=" Positive result was obtained.

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

"J" When the associated value is an estimated quantity, indicating a decreased knowledge of the accuracy or precision of the reported value.

"UJ" When the analyte was analyzed for, but it was not detected above the minimum detectable value, and the reported value is an estimate, indicating a decreased knowledge of the accuracy or precision of the reported value.

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

A positive result will be flagged with a "J" qualifier and non-detect results will be flagged "UJ" when data quality is suspect due to quality control issues, either blank contamination or analytical interference. None of the laboratory data were assigned an "R" code. SAIC validation qualifiers and reason codes and copies of validation checklists and qualified data forms are filed with the analytical hard copy deliverable.

4.0 DATA EVALUATION

The data evaluation process considers precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS). The following sub sections will provide detail to the particular parameters and how the data was evaluated for each with discussion and tables to present the associated data.

Accuracy and precision can be measured by the relative percent difference (RPD) or the normalized absolute difference (NAD) using the following equations:

$$RPD = \left(\frac{|S - D|}{\frac{S + D}{2}} \right) * 100$$

$$NAD = \frac{|S - D|}{\sqrt{U_S^2 + U_D^2}}$$

Where: S = Parent Sample Result
D = Field Split/Duplicate Parent Sample Result
U_S = Parent Sample Uncertainty
U_D = Field Split/Duplicate Parent Sample Uncertainty

The RPD is calculated for all samples, if a detectable result is reported for both the parent and the QA field split or field duplicate. For radiological samples, when the RPD is greater than 30 percent, the NAD is used to determine the accuracy or precision of the method. NAD accounts for uncertainty in the results, RPD does not. The NAD should be below a value of 1.96. Neither equation is used when the analyte in one or both of the samples is not detected. In cases where neither equation can be used, the comparison is counted as acceptable in the overall number of comparisons.

The "SAG Implementation Guidance for Interpretation of QA Split Program" memorandum (USACE 2005a), states that a QA split sample should be collected and analyzed at a frequency of approximately one every twenty samples (5 percent). Combining DT-35 and DT-36, 3 split samples and 3 field duplicate samples were analyzed using both gamma and alpha spectrometry. These represent 5 percent of the 60 systematic, random, biased, and their associated subsurface samples.

4.1 ACCURACY

Accuracy provides a gauge or measure of the agreement between an observed result and the true value for an analysis. For this report, accuracy is measured through the use of the field split samples through a comparison of the prime laboratory results versus the results of an independent laboratory.

4.1.1 Radiological Parameters

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

4.1.2 Inter-Laboratory Accuracy

As discussed above, RPD and NAD were used to measure the analytical accuracy of split sample pairs for two radiological analytical groups (i.e., alpha spectroscopy and gamma spectroscopy). The split sample pairs were analyzed by the FUSRAP laboratory at HISS and an independent contract laboratory, Test America. The ability to compare the results from the laboratories is subject to several factors, such as sample homogeneity, analytical methods, volume of sample, and, for radiological, samples the size of the uncertainty (reported as error) relative to the result (e.g., a low result near the detection limit may have an uncertainty close to or even higher than the result itself). Accuracy is affected by the size of the relative uncertainty in the result. Typically, as the result gets close to the minimum detectable concentration, the relative uncertainty gets larger. Many of the sample results discussed in this report are close to the minimum detectable concentration.

The analytical accuracy between laboratories met the FSS goal of ensuring that 90 percent of the verification samples were within the DQOs. For radiological analysis, the sample results comparison must be less than the 30 percent criteria for RPD, or be less than or equal to 1.96 for NAD to be within the DQOs. For radiological analysis, 3 sample pairs were compared for 12 analytes for a total of 36 comparisons. One comparison, or 2.8 percent, exceeded the criteria as demonstrated in Tables F-1 and F-2. This meets the SAG goal of 90 percent acceptance. The data are acceptable.

Table F-1. Split Accuracy among Alpha Spectroscopy Analyses

Sample Name	Th-228		Th-230		Th-232	
	RPD	NAD	RPD	NAD	RPD	NAD
SLD95145/SLD95145-2	N/A	0.50	NC	NC	NC	NC
SLD95151/SLD95151-2	N/A	0.15	NC	NC	NC	NC
SLD95307/SLD95307-2	**58.3%**	N/A	NC	NC	NC	NC

NC – Value not calculated since one or both of the results were non-detected.

N/A – Not applicable.

Boldface – Values exceed the control limits.

Table F-2. Split Accuracy among Gamma Spectroscopy Analyses

Sample Name	Ac-227		Am-241		Cs-137		K-40		Pa-231		Ra-226		Ra-228		U-235		U-238	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
SLD95145/SLD95145-2	NC	NC	NC	NC	NC	NC	20.7%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD95151/SLD95151-2	NC	NC	NC	NC	NC	NC	13.4%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD95307/SLD95307-2	NC	NC	NC	NC	NC	NC	17.9%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

Am – Americium

Cs – Cesium

NC – Value not calculated since one or both of the results were non-detected.

N/A – Not applicable.

4.2 PRECISION

4.2.1 Analytical Precision

Precision is a measure of mutual agreement among individual measurements performed under the same laboratory controls. To evaluate precision, a field duplicate sample is submitted to the same the HISS laboratory along with the original sample. Both samples are analyzed under the same laboratory conditions. If any bias was introduced at the laboratory, that bias would affect both samples equally.

Field duplicate samples were employed at a frequency of one duplicate sample per 20 samples. As a measure of analytical precision, the RPDs for these field duplicate sample pairs for the two radiological analytical groups (i.e., alpha spectroscopy and gamma spectroscopy) were calculated at the time of verification and validation. RPD (and/or NAD) values for all analytes were within the 30 percent window (less than or equal to 1.96) of acceptance for the verification samples, except where noted.

4.2.2 System 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 samples. Soil samples were collected from the same sampling device, after homogenization for all analytes.

For the three field duplicate samples taken for the verification activities, the NAD and RPD values indicated acceptable precision for the data. For radiological analysis 12 analytes were compared for 3 field duplicate pairs for a total of 36 comparisons. None of the comparisons exceeded the criterion as demonstrated in Tables F-3 and F-4. This meets the SAG goal of 90 percent acceptance. The data are acceptable.

Table F-3. Field Duplicate Precision among Alpha Spectroscopy Analyses

Sample Name	Th-228		Th-230		Th-232	
	RPD	NAD	RPD	NAD	RPD	NAD
SLD95145/SLD95145-1	N/A	0.39	NC	NC	NC	NC
SLD95151/SLD95151-1	N/A	0.13	NC	NC	NC	NC
SLD95307/SLD95307-1	13.2%	N/A	NC	NC	NC	NC

NC – Value not calculated since one or both of the results were non-detected.

N/A – Not applicable.

Table F-4. Field Duplicate Precision among Gamma Spectroscopy Analyses

Sample Name	Ac-227		Am-241		Cs-137		K-40		Pa-231		Ra-226		Ra-228		U-235		U-238	
	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD	RPD	NAD
SLD95145/SLD95145-1	NC	NC	NC	NC	NC	NC	0.3%	N/A	NC	NC	3.6%	N/A	NC	NC	NC	NC	NC	NC
SLD95151/SLD95151-1	NC	NC	NC	NC	NC	NC	0.1%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD95307/SLD95307-1	NC	NC	NC	NC	NC	NC	8.0%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC – Value not calculated since one or both of the results were non-detected.

N/A – Not applicable.

4.3 SENSITIVITY

Determination of MDC values allows the investigation to assess the relative confidence that 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 MDC, the less confidence and more variation the measurement will have. Project sensitivity goals were expressed as quantitation level goals in the FSSP. These levels were achieved or exceeded throughout the analytical process.

The MDC is reported for each result obtained by laboratory analysis. These very low MDCs are achieved through the use of gamma spectroscopy for radionuclides other than thorium, and alpha spectroscopy for thorium. The varying MDCs for the same analyte reflects variability in the detection efficiencies and conversion factors due to influences such as individual sample aliquot, sample density, and variations in analyte background radioactivity at the laboratory. In order to complete the data evaluation (i.e., precision, accuracy, representativeness, and comparability), analytical results are desired that exceed the MDC of the analyte.

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. 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.

Tables F-5 and F-6 contain the results used to compare sample results from the field duplicate and split samples to the associated parent sample for alpha spectroscopy and gamma spectroscopy, respectively. In these tables, the Ra-226 results from the independent laboratory have been adjusted upward by a factor of 1.5, for all samples analyzed after February 20, 2002, to provide proper comparability. The adjustment is necessary since the Ra-226 results reported by the FUSRAP Laboratory automatically include a factor of 1.5 to conservatively account for Ra-226 in-growth. The independent laboratory does not include a factor to account for Ra-226 in-growth.

Table F-5. Alpha Spectroscopy Results for Parent Samples and the Associated Field Duplicates and Field Splits

Sample Name	Th-228	Th-230	Th-232
SLD95145	0.65	2.79	1.03
SLD95145-1	0.86	1.76	0.48
SLD95145-2	0.87	2.37	0.95
SLD95151	0.93	1.21	0.69
SLD95151-1	0.84	1.54	0.80
SLD95151-2	0.85	1.28	0.71
SLD95307	1.86	1.82	1.33
SLD95307-1	1.63	1.51	1.04
SLD95307-2	1.02	1.43	1.12

Table F-6. Gamma Spectroscopy Results for Parent Samples and the Associated Field Duplicates and Field Splits

Sample Name	Ac-227	Am-241	Cs-137	K-40	Pa-231	Ra-226	Ra-228	U-235	U-238
SLD95145	0.16	0.04	-0.01	8.74	0.30	2.76	0.75	0.26	2.18
SLD95145-1	0.17	0.03	-0.01	8.71	0.24	2.86	0.75	0.25	1.79
SLD95145-2	0.11	0.03	0.02	7.10	-1.00	2.28[a]	0.65	-0.13	1.21
SLD95151	0.06	0.01	-0.03	7.09	0.42	1.45	0.71	0.04	0.92
SLD95151-1	-0.17	-0.02	0.00	7.10	0.27	1.38	0.57	0.08	1.34
SLD95151-2	0.02	-0.02	0.01	6.20	-0.10	1.44[a]	0.70	0.02	0.53
SLD95307	-0.05	0.06	0.08	18.30	0.02	0.98	1.18	0.04	0.73
SLD95307-1	0.07	0.00	-0.03	16.90	0.52	1.09	1.20	-0.14	1.42
SLD95307-2	0.09	0.05	-0.01	15.30	-0.90	1.55[a]	1.12	-0.05	1.06

[a] Value corrected by a factor of 1.5 for comparability.

4.5 COMPLETENESS

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

A total of 60 systematic, random, biased, and subsurface soil samples were collected with approximately 985 discrete analyses being obtained, reviewed, and integrated into the assessment. The project produced acceptable results for 100 percent of the sample analyses performed.

5.0 DATA QUALITY ASSESSMENT SUMMARY

The overall quality of this evaluation information 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.

Sample 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. Comparisons that have exceeded the requirements have bolded type. There are numerous possibilities for these anomalies:

- Dilution of samples due to high analyte concentration that exceeds analytical calibration
- Excessive dilution for sample turbidity or other matrix issues that was deemed necessary for a laboratory analysis
- Incomplete sample homogenization either at the laboratory or during the field sampling
- Matrix interferences within the sample itself that caused inadequate analytical quantitation
- Different preparation methods for the sample at different laboratories
- Different analytical methods for the samples at different laboratories
- Low concentration of the analyte for the calibration range, or near the method detection limit for that analyte, etc.

Further analysis of the data can display trends or even randomness within the data set that could be explained with one or more of the above mentioned contributors to anomalies. For instance, a single sample analyzed at two different laboratories that shows the RPD was not met for any analyte; this could be an indicator of incomplete homogenization in the field, matrix effects in the sample, different preparation methods, dilutions that were required to overcome sample concentration, or analyte concentrations approaching the method detection limit. The same analyte within a sample while other analytes are within specifications could be a simple matrix effect causing poor quantitation of a sample or low concentration of the actual analyte. If a lab has numerous out of specification data for a specific analyte versus another lab; preparation of the sample could be suspect between labs or even equipment calibration for the specific analyte could be called into question. Laboratory data that shows exceeded RPD for a sample pair analyzed in the same lab but none for the same analyte sample pairing when compared to another lab could be attributed to randomness of quantitation within the analysis.

The DoD QSM defines allowable marginal exceedances as 10 percent of the total analysis for random anomalies that occur during regular laboratory analysis. As presented in this report, there are 72 total comparisons with 1 exceedance, or 1 percent, well within the DoD QSM allowance. The requirements for the project have been met for 90 percent of the data to be acceptable, which allows for some noticeable trends and randomness of anomalous exceedances between laboratories.

Data produced for this QCSR demonstrates that it can withstand scientific scrutiny, are appropriate for its intended purpose, are technically defensible, and are 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.

APPENDIX G

RISK AND DOSE ASSESSMENT

RISK AND DOSE ASSESSMENT

RISK AND DOSE ASSESSMENT MODEL

RESRAD (RESidual RADioactivity) is a computer model developed by the Argonne National Laboratory for the DOE. RESRAD calculates site-specific risk and dose to various future hypothetical on-site receptors at sites that are contaminated with residual radioactive materials. The use of RESRAD codes for modeling risk and dose has become an acceptable industry practice among prominent federal agencies. For example:

- The EPA used RESRAD in its "Reassessment of Radium and Thorium Soil Concentrations and Annual Dose Rates" that demonstrated the protectiveness of the Uranium Mill Tailing Radiation Control Act soil criteria and in its rulemaking for cleanup of sites contaminated with radioactivity.
- Seven U.S. Cabinet-level agencies including the EPA, DOE, NRC, and DoD, functioning as the Interagency Steering Committee on Radiation Standards formally accepted RESRAD-BIOTA.
- The EPA was also a signatory to both the SLDS ROD and the *Record of Decision for the North St. Louis County Sites* (USACE 2005b), both of which used RESRAD in their development. EPA has participated in many other CERCLA actions involving RESRAD.

Version 6.3 was used to calculate potential risk and dose to the scenario receptor. Residual risk and dose assessments for the ROD were performed using RESRAD Version 5.62. RESRAD 5.62 incorporates the morbidity slope factors from the *Health Effects Assessment Summary Tables (HEAST): Table 4* (EPA 1995), whereas RESRAD 6.3 incorporates morbidity slope factors from the *Cancer Risk Coefficients for Environmental Exposure to Radionuclides, Federal Guidance Report 13* (EPA 1999) that are pathway specific.

RECEPTOR SCENARIO

The input parameters selected for the utility and industrial worker scenarios are those defined in the SLDS FS. The exposure parameters selected for the onsite residential receptor scenario are those defined for the onsite residential receptor in the *Post-Remedial Action Report for the St. Louis Downtown Site Plant 2 Property* (USACE 2002c). Input parameters for the hydrological data (site soil and water properties) for all scenarios were selected or determined from the *Baseline Risk Assessment for Exposure to Contaminants at the St. Louis Site* (DOE 1993), SLDS FS, and RESRAD guidance.

Each receptor scenario is summarized as follows:

- 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-site, early daily arrival, and late daily departure.
- 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.
- On-Site Residential Receptor: The on-site residential receptor is modeled as a potential future receptor in case the current land use areas being assessed changes to residential.

From the *Risk Assessment Guidance for Superfund: Volume 1—Human Health Evaluation Manual* (EPA 1989), the residential receptor is assumed to live on site for 350 days per year for 30 years. The resident is assumed to spend 16.4 hours indoors and 2.0 hours outdoors each day per the *Exposure Factors Handbook, Volumes 1, 2, and 3* (EPA 1997b). Among outdoor activities, the resident is assumed to spend 0.2 hours each day for gardening.

The exposure pathways applicable to the radiological risk and dose assessment are external gamma, inhalation, and soil ingestion for the three scenarios, with plant ingestion added for the on-site resident scenario. Since groundwater is not a potential source of drinking water for SLDS, the drinking water pathway is not considered a potential pathway for the property (USACE 1998a). The non-default RESRAD input parameters for the receptor scenarios are presented in Table G-1.

Table G-1. RESRAD Non-Default Input Parameters

Category	Parameter	Values		
Physical Parameters	Area of Contaminated Zone (m²)	DT-35, SU-01	5,299	
		DT-36, SU-02	3,665	
		Combined Area	8,964	
	Thickness of the Contaminated Zone (m)	2		
Cover Parameters	Cover Depth (m)	0		
	Density of the Cover Matcrial (g/cm³)	Not Applicable		
	Cover Erosion Rate (m/yr)	Not Applicable		
Hydrological Data for Contaminated Zone	Density of Contaminated Zone (g/cm³)	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/yr)	0.92		
	Irrigation (m/yr)	0		
	Run-off Coefficient (unitless)	0.8 (Built-Up Area)		
	Contaminated zone Erosion Rate (m/yr)	0.00006		
Exposure Parameters		**On-Site Resident**	**Utility Worker**	**Industrial Worker**
	Inhalation Rate[a] (m³/yr)	8,400	10,550	10,550
	Mass Loading for Inhalation (g/m³)	5.9×10^{-6}	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[b] (unitless)	0.655	0	0.1969
	Outdoor Time Fraction[c] (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

[a] Inhalation rate is based upon 0.96 m³/hr * 8760 hr/yr = 8,400 m³/yr or 1.2 m³/hr * 8760 hr/yr = 11,550 m³/yr.

[b] Fraction of Time Indoor per year (On-Site Resident) = (16.4 hrs/day * 350days/yr) / (24 hrs/day * 365 hrs/day) = 0.655

[c] Fraction of Time Outdoor per year (On-Site Resident) = (2 hrs/day * 350 days/yr) / (24 hrs/day * 365 hrs/day) = 0.0799

DETERMINATION OF SOURCE TERM

Risk and dose for DT-35 and DT-36 is determined by developing a source term and applying that source term to the three receptor scenarios using RESRAD. For these properties, the source terms are based upon exposure point concentrations (EPCs). EPCs for applicable COCs are calculated for each survey unit and the total property. The EPCs for each survey unit are determined by subtracting the average background concentration from the smaller of the 95% upper confidence limit (UCL_{95}) or the maximum detection concentration.

Determination of the UCL_{95} for each radionuclide depends upon the distribution of the sampling results. EPA's designed software ProUCL (version 4.0) was used during the determination of distribution of sampling results. The software determines the UCL_{95} based on the distribution of the sampling results. DT-35 includes one survey unit and DT-36 includes one survey unit. The survey unit of DT-35 included both systematic and biased samples. The survey unit of DT-36 included both random and biased samples. In each survey unit, a representative area equal to the survey unit area divided by the number of systematic or random sampling locations was established for each systematic or random sampling location. Systematic or random 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 systematic or random, and biased samples within that representative area. Representative area COC area-weighted average concentrations were used to determine the UCL_{95} values. Area weighting of samples for each representative area was calculated using the following equation.

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

Where: C_{RA} = Concentration of the representative area
C_S = Concentration of the systematic or random 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 or random sample location (e.g., samples at different depths)

The sample results do not include Pb-210 and U-234, which are contaminants of concern having negligible contributions. However, these radionuclides have relationships to other radionuclides for which a C_{RA} has been calculated. From Table 2.15 of the *Baseline Risk Assessment for Exposure to Contaminants at the St. Louis Site* (DOE 1993), the C_{RA} for Pb-210 is 1.3 times the C_{RA} for Ra-226 and the C_{RA} for U-234 is 1.0 times the C_{RA} for U-238.

DETERMINATION OF EPCS

The EPCs for radionuclide COCs were determined for each data set. The EPCs for the radionuclides were used as representative concentrations to which a receptor was exposed at DT-35 and DT-36. The EPCs for each data set were determined by subtracting the average background concentration from the smaller of either the UCL_{95} or the maximum detected concentration for each data set.

EPA's software "ProUCL" was used to determine the distribution of sampling results, and the UCL_{95} value for each radionuclide, based on the distribution of the sampling results. The sampling results for each sample were given the same area weighting (i.e., area weighting was not performed to reduce the effect biased sampling results can have on a data set).

For each data set, Table G-2 presents the summary statistics, EPC results for each survey unit, and EPC results for DT-35 and DT-36 combined. In addition, the EPCs for the unavailable radionuclides (Pb-210 and U-234) were determined based on the relationship previously discussed. All statistics are based upon the representative area concentration values used to determine UCL_{95} values for each SU.

Table G-2. Exposure Point Concentrations

Survey Unit	Statistic	Radionuclide Concentrations (pCi/g)										
		Ra-226	Pb-210[a]	Th-230	U-238	U-234[a]	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231
DT-35 Class 2 SU-1 (Area 5,299 m²)	Background	2.78	-	1.94	1.44	-	0.09	1.09	0.95	1.16	0.14	0.89
	Maximum	3.75	-	3.52	3.74	-	0.26	1.54	1.14	1.45	0.09	0.52
	Distribution	N	-	N	N	-	N	N	N	N	N	N
	UCL-95	2.97	-	2.85	2.61	-	0.17	1.23	1.02	1.18	0.06	0.27
	EPC	0.19	-	0.91	1.17	-	0.08	0.14	0.07	0.02	0.00	0.00
DT-36 Class 3 SU-2 (Area 3,665 m²)	Background	2.78	-	1.94	1.44	-	0.09	1.09	0.95	1.16	0.14	0.89
	Maximum	1.35	-	1.87	1.21	-	0.10	1.51	1.01	1.50	0.07	0.25
	Distribution	N	-	N	N	-	N	N	N	N	N	N
	UCL-95	1.31	-	1.82	1.11	-	0.08	1.29	0.97	1.37	0.04	0.19
	EPC	0.00	-	0.00	0.00	-	0.00	0.20	0.02	0.21	0.00	0.00
Site (Area 8,964 m²)	Area Weighted EPC	0.11	0.14	0.54	0.69	0.69	0.05	0.16	0.05	0.10	0.00	0.00

[a] EPCs were determined based on the relationship presented in FS Table 2.15.

N – Normal

RISK AND DOSE ASSESSMENT RESULTS

For the scenarios assessed, the highest residential risk and dose were 7×10^{-5} and 3 mrem/yr, respectively. These results met the CERCLA risk range and were below the dose criteria of 25 mrem/yr. EPC calculations (including Pro-UCL output files) and RESRAD output files are on file as part of the St. Louis FUSRAP records/files.

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