REVISION 0

POST-REMEDIAL ACTION REPORT FOR THE ACCESSIBLE SOILS WITHIN THE ST. LOUIS DOWNTOWN SITE MIDTOWN GARAGE VICINITY PROPERTY (DT-29)

ST. LOUIS, MISSOURI

OCTOBER 18, 2005

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

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ACRONYMS AND ABBREVIATIONS

Ac-227	actinium-227
AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
AD	Adverted dose
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
bgs	below ground surface
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm	centimeter
cm^2	square centimeters
COC	contaminant of concern
CQCP	Contractor Quality Control Plan
DOD	Department of Defense
DOE	Department of Energy
dpm	disintegrations per minute
DQA	data quality assessment
DQI	data quality indicator
DQO	data quality objective
DT-29	Midtown Garage Vicinity Property
EPA	Environmental Protection Agency
EPC	exposure point concentration
FFA	Federal Facilities Agreement
FS	Feasibility Study
FSSP	Final Status Survey Plan
ft	foot or feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
g/cm^3	grams per cubic centimeter
g/m^3	grams per cubic meter
g/yr	grams per year
HASL	Health and Safety Laboratory
HISS	Hazelwood Interim Storage Site
HTZ	biased soil sample collected in the final status survey process
IT	International Technology Corporation
IVC	Independent Verification Contractor
kg/yr	kilograms per year
LBGR	lower bound of the grey region
LCS	laboratory control sample
m	meter
m^2	square meters
m^3	cubic meters
m^3/hr	cubic meters per hour
m^3/yr	cubic meters per year
m/s	meters per second

ACRONYMS AND ABBREVIATIONS (Cont'd)

m/yr	meters per year
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineer District
mg	milligrams
mg/day	milligrams per day
mg/m^3	milligrams per cubic meter
mrem	millirem
mrem/yr	millirem per year
MS	Matrix spike
NA	not available
N/A	not applicable
NaI	sodium iodide
NAD	normalized absolute difference
NC	not calculated
NCP	National Oil and Hazardous Substances Contingency Plan
NRC	Nuclear Regulatory Commission
O&M	operation and maintenance
OU	operable unit
pCi/g	picoCuries per gram
Pa-231	protactinium-231
PE	performance evaluation
PW	Present Worth
PRAR	Post-Remedial Action Report
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
QCSR	Quality Control Summary Report
Ra-226	radium-226
Ra-228	radium-228
RA	remedial action
RAC	remedial action contractor
RAO	remedial action objective
RAS	Remedial Action Summary
RESRAD	Residual (RES) Radioactive (RAD)
RG	remediation goal
RI	Remedial Investigation
RPD	relative percent difference
ROD	Record of Decision
SAG	Sampling and Analysis Guide
SAIC	Science Applications International Corporation
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
SOR	sum of ratios
SOR_N	sum of ratios (net)

ACRONYMS AND ABBREVIATIONS (Cont'd)

SU	survey unit
TEDE	Total Effective Dose Equivalent
TERC	Total Environmental Restoration Contract
Th-230	thorium-230
Th-232	thorium-232
U-235	uranium-235
U-238	uranium-238
UCL_{95}	95% upper confidence limit
UMTRCA	Uranium Mill Tailings Radiation Control Act
U.S.	United States
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VP	vicinity property
VQ	validation qualifier
WASD	Work Area-Specific Description
WRS	Wilcoxon Rank Sum
yr	year

PROJECT ABSTRACT

Site Name and Operable Unit:	St. Louis Downtown Site (SLDS) Accessible Soils and Ground-water Operable Unit; DT-29 (Midtown Garage) Parcel
Location:	St. Louis, Missouri
Regulatory Oversight:	United States Environmental Protection Agency (EPA), Region 7 and Missouri Department of Natural Resources (MDNR)
Contractor Oversight:	United States Army Corps of Engineers (USACE), St. Louis District
Remedial Action Contractor: Verification Contractor:	Shaw Environmental, Inc. Science Applications International Corporation (SAIC)
Waste Source:	Manhattan Engineer District / United States Atomic Energy Commission (MED/AEC) Operations
Contaminants:	Radiological. Radionuclides from the uranium (U)-238, thorium (Th)-232, and U-235 decay series.
Technology:	Remediation by excavation of MED/AEC contaminated soil.
Remediation Type:	The *Record of Decision for the St. Louis Downtown Site, St. Louis, Missouri* (ROD) (USACE, 1998a) addresses contamination in accessible soils by excavation and out-of-state disposal and ground-water monitoring.
Purpose/Significance of Application:	Excavation of soils to reduce radionuclide concentrations below ROD remediation goals (RGs) and backfill with USACE approved off-site borrow material.
Type/Quantity of Media Treated:	Soil Removed: 51 bank cubic yards
Period of Operation:	Excavation & Restoration: 10/23/2004 and 10/30/2004
Regulatory Requirements/ Remediation Goals:	In accordance with the ROD (USACE, 1998a), reduce radiological activity in soils such that: 1) the sum of the ratios (SOR) for the above background concentration in surface soils, averaged over any $100m^2$ area, is less than 1.0 when compared to 5 picoCuries per gram (pCi/g) for the greater of radium (Ra)-226 or Th-230, 5 picoCuries per gram (pCi/g) for the greater of Ra-228 or Th-232, and 50 pCi/g for U-238; 2) the SOR for the above background concentration in subsurface soils, averaged over any $100m^2$ area, is less than 1.0 when compared to 15 pCi/g for the greater of Ra-226 or Th-230, 15 pCi/g for the greater of Ra-228 or Th-232, and 50 pCi/g for U-238; and 3) the total dose from residual activity in soils containing materials licensed by the United States Nuclear Regulatory Commission (NRC) commingled with MED/AEC - related wastes does not exceed 25 millirems per year (mrem/yr) to the average member of the critical group as required by 10 CFR (Code of Federal Regulations) 20 Subpart E for any Formerly Utilized Sites Remedial Action Program (FUSRAP) materials similar to licensable materials under the Atomic Energy Act. A monitoring program for ground water is required for the SLDS until discontinued pursuant to the five year Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) review. No ground-water monitoring wells exist on DT-29.
Results:	The residual radioactivity in soils on the area assessed at DT-29 meet all requirements specified in the ROD. This conclusion is the result of comparison of ROD RGs with the residual site concentrations in accessible areas. The concentration-based RGs for Th-230, Ra-226, Th-232, Ra-228, and U-238 are satisfied, noting that no sum of ratios (net) (SOR_N) value equals or exceeds the limit of 1.0 when averaged over any survey unit (SU). Residual radioactive material concentrations of Ra-226 averaged over any $100m^2$ areas did not exceed the background level by greater than 5 pCi/g averaged over the surface soil and greater

PROJECT ABSTRACT (CONT'D)

Results (Cont'd):	than 15 pCi/g averaged over subsurface soil. The above criteria were also met by the residual radioactive material concentrations of Ra-228, Th-230, and Th-232. The dose-based applicable or relevant and appropriate requirement (ARAR) from 10 CFR 20 Subpart E, *Radiological Criteria for License Termination*, has been satisfied, noting that the highest residual dose calculated for DT-29 is <25 millirem per year (mrem/yr) for all modeled scenarios and are fully protective of human health and the environment without regard to the existence of cover materials. The residual risk calculated for DT-29 meets the CERCLA target risk range of 10^{-6} to 10^{-4} for all modeled scenarios and are fully protective of human health and the environment without regard to the existence of cover materials. The SLDS DT-29 Class 1 SUs also satisfy the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (DOD, 2000) statistical requirements since they passed the Wilcoxon Rank Sum (WRS) statistical test as required. The DT-29 SUs meet criteria for release without restrictions in accordance with the ROD.
Cost:	$70,070
Description:	From 1942 until 1957 Mallinckrodt Chemical Works was contracted by the MED and the AEC to process uranium ore for the production of uranium metal. Residuals of the process containing elevated levels of radium, thorium, and/or uranium were released into the environment via air and water. At various times from 1942 to 1957, Plants 1, 2, 4 (now Plant 10), 6, and 7 were involved in the development of uranium-processing techniques or the processing of uranium compounds or uranium-bearing ores. Process residues from these operations were stored at the St. Louis Airport Site (SLAPS) and subsequently relocated to the Hazelwood Interim Storage Site (HISS). Mallinckrodt Plants 1 and 2 were decontaminated from 1948 through 1950 to the criteria then in effect, and the AEC released these plants for use without radiological restrictions in 1951. Plants 4, 6, and 7 were subsequently decontaminated and decommissioned by 1961 and returned to Mallinckrodt Chemical Works for unrestricted use. Soil characterization results at the SLDS indicated that the areas associated with MED/AEC activities were principally affected by radionuclides. Metals were also detected at the SLDS, but are generally co-located with the radionuclides. DT-29 was not sampled for metals. The ROD (USACE, 1998a), which addresses remediation of these MED/AEC wastes at the SLDS was signed in August 1998. Excavation of contaminated soils occurred on DT-29. Excavated soils were loaded into rail cars and shipped to a properly permitted out-of-state disposal facility. The property owner requested that the remediation of DT-29 be performed after regular business hours to avoid economic impact to the business; therefore, remedial activities were performed on Saturday, October 23, 2004 and restoration occurred on Saturday, October 30, 2004.

1.0 INTRODUCTION

The remedial action contractor (RAC) under the direction of the United States Army Corps of Engineers (USACE), St. Louis District, Formerly Utilized Sites Remedial Action Program (FUSRAP), has characterized, designed and completed a remedial action on a portion Midtown Garage Vicinity Property (VP) (DT-29), within the St. Louis Downtown Site (SLDS), St. Louis, Missouri. Herein, reference to DT-29 refers only to the Class 1 survey unit areas of DT-29 as shown on Figure C-2-1 in Appendix C. The SLDS consists of the Mallinckrodt Chemical Works property (Mallinckrodt Property), owned by Mallinckrodt, Inc (Mallinckrodt), and the surrounding vicinity properties. The remedial action consisted of excavating soils at DT-29 to reduce contaminant concentrations associated with Manhattan Engineer District/Atomic Energy Commission (MED/AEC) operations to acceptable levels, and backfilling with USACE approved off-site borrow materials. The remedial action took place on Saturday, October 23, 2004 and restoration was completed on Saturday, October 30, 2004. This Post-Remedial Action Report (PRAR) summarizes the remedial activities, as well as the Final Status Survey Evaluation, that were performed.

The remediation on DT-29 represents only a portion of the remedial action that will occur at the SLDS. Therefore, the general mobilization activities of establishing the project construction office, equipment/materials storage yard(s), water treatment plant, contaminated soils storage and load out facility, and other facilities common to the SLDS remediation activities are not discussed in this report.

Performance factors for the remedial action (RA) completed at DT-29 are discussed in Appendix A of this PRAR. A summary of project costs is provided in Appendix B. Site figures related to the RAs, as well as summary of the Final Status Survey Evaluation, are included in Appendix C.

1.1 Site Description

DT-29 is located at 3227 North Broadway Street and covers approximately 0.47 acres (see Figure C-1-1). The property includes two adjoining buildings with a covered bay and a hoist along the western side of the property. Over 90 percent of the property is paved with asphalt and the remainder, a 20-foot by 80-foot section on the north, is covered with gravel. Outdoor areas are used for parking and storage, and the property slopes gently from northwest to southeast. This document discusses only the two Class 1 survey units (SU) that were defined on the southern end of the property under the main entrance driveway to the property. These Class 1 areas are defined as DT-29 throughout the rest of the document.

1.2 Site History

1.2.1 Relevant Operations and Waste Management Practices

Mallinckrodt has used, blended, and manufactured organic and inorganic chemicals since 1867. Mallinckrodt was contracted by MED and the AEC from 1942 until 1957 to process uranium ore for the production of uranium metal.

Residuals of the uranium metal production process, including spent pitchblende ore and process chemicals, were inadvertently released from the Mallinckrodt Property and into the environment through handling and disposal practices. Residuals from this process had elevated levels of radium, thorium, and uranium and impacted surface and subsurface soils at a variety of properties within the SLDS.

Soil samples indicate thorium, uranium, and radium contamination is widespread across the SLDS. Remediation clean-up levels are derived from the primary site contaminants radium-226 (Ra-226), radium-228 (Ra-228), thorium-230 (Th-230), thorium-232 (Th-232), and uranium-238 (U-238) as remediation of these radionuclides will assure that all radioactive contaminants are addressed. Contaminants with sum of ratios (SORs) greater than or equal to one were confined to surface soils.

1.2.2 Regulatory History

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

In June 1990, the Environmental Protection Agency (EPA) Region VII and DOE entered into a CERCLA Section 120 Federal Facilities Agreement (FFA). In the FFA, DOE agreed to conduct response actions for all wastes, including but not limited to radiologically contaminated wastes and other chemical or radiological wastes that have been mixed or commingled with wastes resulting from or associated with MED/AEC uranium manufacturing or processing activities conducted at the SLDS.

In October 1997, the U.S. Congress transferred responsibility for FUSRAP from the DOE to the USACE through the 1998 Energy and Water Development Appropriations Act.

1.2.3 Previous Investigations

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

In 1994, a Remedial Investigation (RI) (DOE, 1994) was completed in accordance with CERCLA to determine the nature and extent of contamination in soil, sediment, and ground water at the SLDS. Sampling activities revealed radiological constituents present at detectable levels in soil, sediment, and ground water. Soil characterization activities, in particular, indicated that the areas associated with MED/AEC activities were contaminated with radionuclides, including radium, thorium, uranium, and their decay products.

In April 1998, a Feasibility Study (FS) (USACE, 1998b) for the SLDS was prepared and released for public comment to identify, develop, and evaluate remedial action alternatives for the site (in accordance with CERCLA guidance) based on the nature and extent of contamination documented in the RI. Six sitewide remedial action alternatives were evaluated for the SLDS.

In August 1998, the *Record of Decision for the St. Louis Downtown Site* (ROD) (USACE, 1998a) was signed by the USACE and the EPA and addressed contamination related to MED/AEC activities in accessible soils and ground water. The selected remedy for this Operable Unit (OU), Alternative 6 of the FS - Selective Excavation and Disposal, is the final RA for accessible soils and ground water beneath the SLDS for MED/AEC-related hazardous substances.

2.0 OPERABLE UNIT BACKGROUND

This OU consists of the accessible soils and ground water contaminated as a result of MED/AEC uranium manufacturing and processing activities at the SLDS. Inaccessible soils and associated building and structures will be addressed in a separate CERCLA action.

2.1 Remedial Action Objectives

Remedial action objectives (RAOs) specify specific contaminants, media of concern, potential exposure pathways, and remediation goals (RGs). RAOs are based on the nature and extent of contamination, threatened resources, and the potential for human and environmental exposure.

Soils at the SLDS were characterized in the Baseline Risk Assessment (BRA) (ANL, 1993) as posing potentially unacceptable risks to human health and the environment due to the following MED/AEC related radiological contaminants of concern (COCs): Th-230, Th-232, Ra-226, Ra-228, U-235, U-238, and their respective radioactive decay products. Arsenic and cadmium are non-radiological COCs that may have been introduced by MED/AEC operations, but since DT-29 is not in uranium ore processing areas, non-radiological COCs are not of concern for the RA at DT-29. The primary contribution to risk from uranium at the VPs results from the radioactivity present. Remedial alternatives developed to address contamination in soils considered elimination or mitigation of the exposure pathways listed above as well as compliance with guidelines presented in Table 2-1.

Table 2-1. Remedial Action Objectives for Remediation of the SLDS Operable Unit

Medium	Remedial Action Objective
Soil	Prevent exposures from surface residual contamination in soils greater than the criteria prescribed in 40 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 ARARs
	Eliminate or minimize potential exposure to external gamma radiation
Ground water	Remove sources of COCs in the shallow groundwater
	Continue to maintain low concentrations of OU COCs in the deeper groundwater

2.2 Selected Remedy

The selected remedy, as excerpted from the ROD (USACE, 1998b) for the Accessible Soils OU, includes:

1. *"Excavation of accessible soils according to the applicable or relevant and appropriate requirement (ARAR)-based composite cleanup criteria of 5/15 picoCuries per gram (pCi/g) (surface/subsurface) above background concentrations for Ra-226, Ra-228, Th-232, and Th-230, and 50 pCi/g above background concentrations for U-238" in the soil throughout the OU.*
2. *"Remediation goals for radiological contaminants are applied to soil concentrations above background consistent with the ARAR (40 Code of Federal Regulations*

(CFR) 192), from which they derive. However, addition of background concentrations to these goals would not alter any judgments regarding protectiveness."

3. *"Compliance with soil contamination criteria will be verified by methods that are compatible with MARSSIM for soils being cleaned up in the OU, effective with MARSSIM publication."*
4. *"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;"*
5. *"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 [National Oil and Hazardous Substances Pollution Contingency Plan] NCP for residual conditions that are unsuitable for unrestricted use.*
6. *"Protactinium (Pa)-231 and actinium (Ac)-227 will be included in the analyses for the post-remedial action residual site risk." (USACE, 1998b)*

The selected remedial alternative includes excavation of accessible Mallinckrodt property soils within the upper four or six feet (ft) below ground surface (bgs) to ARAR-based composite criteria. Only approved off-site borrow material will be used to fill excavations at the SLDS. Potential ground water degradation will be controlled by excavation of sources of soil contamination, implementing applicable institutional controls, and providing perimeter ground-water monitoring to achieve post-remediation compliance.

As required by the ROD, final status surveys were performed within DT-29 in accordance with the protocols established in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (U. S. Department of Defense [DOD], et al, 2000). The MARSSIM is a multi-agency document that describes a consistent approach for planning, performing and assessing final status surveys to meet established dose or risk-based release criteria. The USACE implemented final status surveys at DT-29 in accordance with the *Final Status Survey Plan for Accessible Soil Within Mallinckrodt Property and the Vicinity Properties, Excluding Plants 1 and 2 and the City Property at the St. Louis Downtown Site, St. Louis, Missouri* (FSSP) (USACE, 2002b).

The presence of multiple contaminants requires that the SOR criterion for soils be satisfied to meet the radionuclide guidelines specified in the ROD. To demonstrate compliance with this criterion, the above-background concentration of each of the primary contaminants is divided by the respective guideline level for that radionuclide to determine a ratio to the guideline. The combined contributions of the COC to the ratio must be less than one to meet the RG. The SOR equations for the surface and subsurface soils intervals as well as the corresponding results for DT-29 are provided in Appendix C.

2.3 Monitoring/O&M Requirements

Operation and maintenance (O&M) of the restored surfaces (i.e. asphalt, concrete and/or gravel) are the responsibility of the property owner by their acceptance of the final inspection reports.

2.4 Remedial Design Summary

The *Small Area Remediation Work Area-Specific Description, FUSRAP St. Louis Downtown Site, St. Louis Missouri*, (Small Area Remediation WASD) (IT, 2001a) describes the common aspects for all small area remediation activities at the SLDS. The *Midtown Garage Vicinity*

Property (DT-29) Remediation Work Description (Shaw, 2004a) describes the specific elements of the planned remediation activities required for DT-29.

Remedial action at DT-29 focused on one area of contaminant concentrations exceeding RGs that had been identified (see Figures C-1-2, C-7-1 and C-7-2). The area was completely covered in asphalt paving. Based upon the sampling results, the area appeared to be shallow. The remedial action took place in one day; therefore, runoff due to precipitation was not expected or encountered during the construction period. Excavated areas were backfilled with clean fill and the asphalt surface replaced.

Potential impact to Midtown Garage operations at their facility was considered during the remedial design of DT-29. The excavation would impact the entrance to the facility. To eliminate issues with facility access, all work was performed on DT-29 during two Saturdays. The first Saturday included the excavation and backfill and the second Saturday was needed to restore the area (replace the asphalt cover).

3.0 CONSTRUCTION ACTIVITIES

3.1 Mobilization and Site Preparation

The excavation area of DT-29 was covered with asphalt that had to be removed prior to remedial activities. Following removal and disposal of the asphalt, gamma walkover surveys and biased sampling were performed to further delineate the limit of contamination for gross excavation. Sample and excavation locations are included in Appendix C, Figures C-1-2 and C-7-1.

A civil survey of the excavation area, including nearby buildings/structures, was conducted to document site conditions.

Exclusion zones, contamination reduction zones, traffic controls, and construction safeguards were established as required.

3.2 Site Work

Soils having elevated radiological activity, as determined by remedial design soil sampling, were removed in accordance with the remedial design excavation depth and transported by truck to the soil load-out area at the Mallinckrodt property soil storage and load out facility. These contaminated soils were then either loaded directly into railcars or stockpiled for future load-out and transportation for final disposal at an out-of-state facility. Gamma walkover surveys and soil sampling at areas of elevated activity were performed to guide excavation by identifying locations of contaminated soil, and to identify when the SLDS concentration-based RGs had been met. If the analytical results from samples collected from the excavated areas indicated that the remediation criteria were not met, then additional excavation, gamma walkovers, and resampling, if require, were performed. This sequence was repeated until the concentration-based RGs were met. After completing the excavation, a civil survey of the excavation limits and contours was performed. Also, preferential pathway analysis and sampling, if required, were performed.

A request for the final status survey including as-built drawings, the most recent results of sampling and additional information about contaminated soil that was inaccessible for remediation, if applicable, was provided to the USACE. Following USACE authorization, a final status survey was performed that consisted of a gamma walkover survey and soil sampling at biased locations within the excavation to verify that SLDS ROD remediation criteria had been met. Final status survey samples were collected at locations defined by a systematic grid in accordance with the FSSP (USACE, 2002). After evaluation of the final status survey sample results in accordance with MARSSIM, and evaluating that the cleanup criteria were met, USACE authorized backfill of the excavation. The exclusion and contamination reduction zone postings were removed, and traffic controls were established as required for the backfilling operation.

Backfilling of the excavations proceeded using USACE approved fill material. Safety controls were removed and the remediated locations were released after inspection and approval by the USACE. No health or safety problems were encountered during the DT-29 RA.

3.3 Sampling Activities

Soil sampling was performed in three phases. The first sampling phase was conducted prior to remediation and consisted of gamma walkover surveys, biased soil sampling, and sampling in a systematic manner to delineate the limit of contamination on the property. The second sampling phase was conducted after excavation of contaminated soil to verify that the excavation areas met cleanup criteria and were ready for final status survey. The third and final soil sampling phase was conducted during the final status survey to confirm that the RAs were successfully completed and that the ROD remediation criteria were met. Sample and gamma walkover information can be found in Appendix C, Figures C-1-2, C-7-1 and C-7-2.

Due to the time constraints imposed on the RA for this property, the final status survey was initiated by the Project Radiation Safety Officer submitting a Final Status Survey Request to the USACE verbally. A formal Final Status Survey Request was provided to the USACE as well. After receiving USACE verbal approval, the final status survey was completed by conducting a gamma walkover survey of the excavation and collecting soil samples at biased and systematic grid locations in accordance with the FSSP. The samples were submitted to the Hazelwood Interim Storage Site (HISS) radiological laboratory, along with quality control samples, under chain-of-custody requirements per the FSSP. The sampling location coordinates were determined by a civil survey. Excavations were backfilled with USACE - approved off-site borrow material.

4.0 CHRONOLOGY OF EVENTS

The chronology of events significant to the RA for DT-29 is summarized in Table 4-1. The construction start dates and backfill authorization dates are indicated by SU since the backfill authorizations were requested and issued by SU.

Table 4-1. DT-29 Chronology of Significant Events

Event	Date Complete
ROD signed	August 27, 1998
Small Area Remediation WASD	May 3, 2001
Sampling Events	March 22, 2004 through October 23, 2004
Start RA Excavation	October 23, 2004
Final Status Survey Complete	October 23, 2004
Backfill Authorization Approved	October 23, 2004
Site Restoration Completed	October 30, 2004
Final Inspection Complete	December 3, 2004

5.0 PERFORMANCE STANDARDS AND CONSTRUCTION QUALITY CONTROL

5.1 Performance Standards

5.1.1 Quantity of Material Treated

Approximately 110 square meters (m^2) (1,190 square feet) of surface area was affected by the DT-29 remediation activities. An estimated 51 bank cubic yards of radiologically contaminated soils were excavated from DT-29. The excavated radiologically contaminated material was shipped to out-of-state licensed and/or properly permitted disposal facility. The wastes were sent to US Ecology Idaho, Inc. (Formerly Envirosafe of Idaho) in Grand View, Idaho for disposal. The SLDS, as defined in the ROD, does not include DT-29 and therefore, remediation volumes and cost cannot be directly compared to those stated in the ROD.

5.1.2 Final Status Survey Sampling and Results

Final status survey sampling strategy was based on MARSSIM guidance resulting in one Class 1 soil survey unit (i.e., SU-1) on DT-29. Soil sampling and surface activity measurements were performed as described in the FSSP (USACE, 2002b). Surface activity measurements were required due to the presence of the consolidated surface in SU-2. The ROD remediation criteria on DT-29 were met in all areas by the excavation and disposal of radiologically contaminated soils at an out-of-state facility. Consolidated materials did not require remediation or disposal. The final status survey sampling strategy, consolidated material surface activity measurements, and soil sampling results are discussed in detail in Appendix C.

5.2 Quality Assurance/Quality Control (QA/QC)

5.2.1 Construction QA/QC Requirements

The purpose of the *Contractor Quality Control Plan, FUSRAP St. Louis Downtown Site, St. Louis, Missouri* (CQCP) (IT, 2001b) is to verify that remedial and construction activities are conducted in accordance with the specified requirements. The requirements for these activities are presented in the Small Area remediation WASD and the *Midtown Garage Vicinity Property (DT-29) Remediation Work Description* (Shaw, 2004a). Quality control was maintained through a three-phase field inspection process and associated checklists. The three-phase inspection process consisted of preparatory, initial, and follow-up inspections. Each definable feature of work falls under one of the following categories: Site Preparation, Site Excavation, Final Status Survey/Sampling, Site Backfill and Surface Restoration.

The objective of the preparatory inspection was to establish and document that required preliminary activities necessary to start an activity had been completed. Preparatory inspections were documented on forms that are retained in Shaw's Total Environmental Restoration Contract (TERC) program office central files in Kansas City, Kansas.

Initial inspections were conducted at the start of applicable definable features of work to document that the work was initiated in accordance with the specified requirements in accordance with the CQCP. Initial inspections documentation is retained in the project files.

Follow-up inspections on work activities were completed to document that work activities continued to be performed in accordance with specified requirements. Follow-up inspections were documented in the daily quality control reports that are retained in the project files.

Upon receipt notification that the SU identified in the final status survey request was authorized for backfill by the USACE, site restoration activities commenced to complete restoration of the location. Copies of the backfill authorization for each survey unit can be found in the project files.

Complete documentation was prepared and maintained during and after construction/remediation activities to demonstrate that the Small Area Remediation WASD and summary description of RA requirements were met.

Project plans and construction specifications affecting the quality of the project were incorporated by reference in the CQCP. In accordance with the CQCP, any variance to the original design included in the Small Area Remediation WASD and the summary description of the RA requirements was documented and authorized by field work variances. There were no field work variances for DT-29 activities.

5.2.2 Data QA/QC Requirements

A Quality Assurance Project Plan (QAPP) was developed for this project and is contained in the *Sampling and Analysis Guide for the St. Louis Sites* (USACE, 2000). This document specifies the quantity and types of quality assurance/quality control (QA/QC) samples to be used to evaluate the quality of the data.

Multiple activities were performed to achieve the desired data quality for this project. A QA program was established to standardize procedures, document activities, and provide a means to detect and correct deficiencies in the process. Data Quality Objectives (DQOs) were established to guide the implementation of the field sampling and laboratory analysis (USACE, 2002b).

In the field, sampling was performed in accordance with the applicable sampling procedures approved for the SLDS (USACE, 2000). Survey personnel were responsible for verifying their instruments were operable and performing within established tolerances on a daily basis both prior to and following the survey measurements for that work shift (SAIC, 2003). In addition, split and duplicate samples were collected for every 20 field samples of each matrix and analyte.

Samples were transferred to the FUSRAP laboratory where radiological analyses were performed as indicated in Appendix A, Table A-1. The laboratory complied with its QC program, which provided the rules and guidelines to ensure the reliability and validity of the work conducted at the laboratory (SAIC, 1999). Compliance with the program was monitored by the laboratory's QA department, which was independent of the operating departments. Upon receipt by the project team, data was subjected to verification and validation review.

See Appendix C, Attachment C-2 for the Quality Control Summary Report (QCSR) of the final status survey sampling data.

6.0 FINAL INSPECTION AND CERTIFICATIONS

6.1 Inspections

As required by the ROD, final status surveys were performed within DT-29 using methods compatible with MARSSIM (DOD, 2000). The USACE implemented final status surveys at DT-29 in accordance with *Radiological Final Status Survey Plan for Accessible Soil Within Mallinckrodt Property and the Vicinity Properties, Excluding Plants 1 and 2 and the City Property at the St. Louis Downtown Site (FSSP)* (USACE, 2002b).

A final inspection, at the conclusion of site restoration, was conducted on December 1, 2004 by the RAC and the USACE. On December 3, 2004 the property owner did the final inspection and accepted the return of the DT-29. The final inspection is documented on the final inspection form and is retained in the project files.

6.2 Certification of Completion

The RAs described in this report are only a portion of the work required to satisfy the RA requirements specified in the ROD. The final inspection report for DT-29 serves as the documentation of completion of the RA required to satisfy the ROD requirements for the Class 1 area of the property. Upon completion of RAs at the SLDS, a final certification of completion will be issued.

6.3 Problems and Deviations

The work was executed in accordance with the approved work plan (Shaw, 2004a) with no deviations.

6.4 Institutional Controls

The dose and risk from actual residual conditions (without regard to cover materials) are acceptable to release DT-29 accessible soils without restrictions. Details of the dose and risk assessment can be found in Appendix C Section C.7.

7.0 OPERATION AND MAINTENANCE (O&M) ACTIVITIES

The O&M of the accessible areas remediated by the USACE or its contractors are not necessary because the areas were remediated to unrestricted use criteria with reference to Appendix C of this document. O&M of the restored surfaces (gravel and concrete) at DT-29 are the responsibility of the property owner by their acceptance of the Final Inspection Report.

8.0 SUMMARY OF PROJECT COSTS

A summary of project costs is provided in Table 8-1. A more detailed cost breakdown is provided in Appendix B.

Table 8-1. Cost Summary

Cost Item	ROD Estimate (1) (1998 $$)	ROD Estimate (2) (2004 $$)	Actual Cost (2004 $$)
RA Capital Cost	$62,910	$73,920	$ 70,070
RA Operating Costs	Not Applicable	Not Applicable	Not Applicable
Total Cost	$62,910	$73,920	$ 70,070
Projected Future O&M Cost	Not Applicable	Not Applicable	Not Applicable

Notes:
(1) The ROD estimate is based on vicinity properties portion of SLDS RA prorated for the actual volume of soil excavated at DT-29.

(2) Feasibility Study cost was adjusted from 1998 dollars to 2004 dollars using average 1998 and average 2004 *Engineering News Record* building cost index factors for RA costs.

9.0 OBSERVATIONS AND LESSONS LEARNED

No observations or lessons learned were realized upon completion of the DT-29 RA.

10.0 OPERABLE UNIT CONTACT INFORMATION

Below is a summary of the contact information for the project team participants:

Project Management: **For the Government:** **Name:** USACE St. Louis District, FUSRAP Project Office **Address:** 8945 Latty Avenue, Berkeley, MO 63134 **Phone Number:** (314) 260-3905 **U.S. EPA Region:** 7
For the Government: **Contract Number:** DACW41-98-D-9006 **Primary Contact Name and Title**: Gerald Allen, Alternate Contracting Officer's Representative **Company Name:** USACE, FUSRAP - SLDS **Address:** #1 Angelrodt Street, St. Louis, MO 63147 **Phone Number:** 314-220-4108
Remedial Action Contractor: **Primary Contact Name and Title:** Bruce Fox, Program Manager **Company Name:** Shaw Environmental, Inc. **Address:** 110 James S. McDonnell Blvd., Hazelwood, MO 63042 **Phone Number:** (314) 895-2137
Survey Contractor **Primary Contact Name and Title:** Sherry Gibson, Program Manager **Company Name:** Science Applications International Corporation (SAIC) **Address:** 8421 St. John Industrial Drive, Suite 200, St. Louis, MO 63114 **Phone Number:** (314) 770-3000
Analytical Laboratory: **Company Name:** USACE FUSRAP Lab (operated by SAIC) **Address:** 8945 Latty Ave., Berkeley, MO 63134 **Phone Number:** (314) 260- 3901 Lab QA/QC by Severn Trent Laboratory **Address:** 13715 Rider Trail North, Earth City, MO 63045 **Phone Number**: 314-298-8566

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APPENDIX A
PERFORMANCE FACTORS

Appendix A: Performance Factors

Performance factors are summarized in Table A-1. Sampling and analysis must meet requirements of the *Sampling and Analysis Guide for the St. Louis Downtown Sites, St. Louis, MO* (USACE, 2000).

Table A-1 Performance Factors

Performance Topic	Type of Information
Types of samples collected: Class 1 and HTZ (i.e., biased sample) Samples	• Radiological soil samples were analyzed for the SLDS radiological COCs.
Sample frequency and protocol for: Class 1 (Systematic Samples) HTZ Samples	• Class 1 samples were collected by either the by Independent Verification Contractor (IVC) or the RAC to document compliance with the ROD RGs. • HTZ samples were collected by IVC at locations that exhibited an elevated count rate during gamma walkover survey. Samples were collected using the hand scoop method (SAIC, 2000a) or by using a hand auger (SAIC, 2000).
Quantity of material treated: Class 1 Excavation Areas Excavation Water Treated	• Approximately 51 bank cubic yards of soil were excavated during the DT-29 remedial activities and transported for disposal. • No excavation water was treated during this RA.
Cleanup goals and/or remediation objectives: Class 1 Samples	The remediation objectives for DT-29 soil samples are as follows: • For surface soils that are 0-6 inch in depth, the SORs of the above background concentration in soils averaged over any 100m^2 area is less than 1.0 when compared to 5 pCi/g for the greater of Ra-226 or Th-230, 5 pCi/g for the greater of Ra-228 or Th-232 and 50 pCi/g for U-238. • For subsurface soils that are greater than 6 inch in depth, the SORs of the concentration in soils averaged over any 100 m^2 area, in any 6 inch layer, is less than 1.0 when compared to 15 pCi/g for the greater of Ra-226 or Th-230, 15 pCi/g for the greater of Ra-228 or Th-232 and 50 pCi/g for U-238.

Table A-1 (continued)

Performance Topic	Type of Information
Comparison with cleanup goals/remediation objectives:	
Class 1 Samples	Final Inspection Surveys for DT-29 and sample results confirmed that RGs had been met. Data from the Class 1 samples are included in Appendix C.
Method of analysis:	
HTZ Samples and Class 1 Samples	• The radiological samples were analyzed by methods prescribed in U.S. DOE Environmental Measurements Laboratory, HASL-300 and ASTM C998-90 and C999-90.
Processed Ground-water Samples	• There are no ground-water monitoring wells located on DT-29 and excavations were shallow so no ground-water was encountered during this RA.
Quality assurance and quality control:	
Class 1 Samples	• The data quality objectives established in the FSSP for Class 1 samples require that 5 percent of the total number of samples be duplicated and split with another laboratory.

APPENDIX B
PROJECT COSTS

Appendix B: Project Costs

Project costs are provided in Table B-1.

Table B-1 Project Costs

Site: FUSRAP – SLDS
Location: St. Louis, MO
Phase: Short form remedial action summary (RAS)
Date: 2/15/05

Description: Remediation of DT-29 Soils Adjacent to Mallinckrodt Facility in St. Louis, Missouri

Cost Element	Amount-2004 Dollars
Area preparation	$2,390
Excavation	$13,120
Engineering during construction	$950
Transportation and Disposal	$16,510
Sampling	$17,000
Restoration	$5,790
Post Remedial Action Report	$7,230
Project and Construction Management	$7,080
Total Project Costs	$70,070

APPENDIX C
FINAL STATUS SURVEY EVALUATION

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LIST OF ATTACHMENTS

C.1 INTRODUCTION

This appendix presents the survey design, data quality assessment (DQA), and results for the final status survey of the SLDS DT-29 (Figure C-1-1). The final status survey was performed in accordance with the requirements of CERCLA and the FSSP and using the guidance provided in the NRC's *NMSS Decommissioning Standard Review Plan* NUREG-1727 (NRC, 2000) and MARSSIM.

One Class 1 (i.e., areas that had radioactive contamination prior to remediation) land area survey unit (i.e., SU-1) and one Class 1 consolidated material survey unit (i.e., SU-2) were established on DT-29, as shown on Figure C-1-2 in attachment 1. The final status survey of SU-1 consisted of a gamma walkover survey and the collection of 21 surface systematic, 22 subsurface samples, and 12 biased soil samples.

During the final status survey of SU-2, alpha and beta scan surveys were performed and 25 systematic measurements were collected for total alpha and total beta activity measurements. The intent of the final status survey was to determine whether the area satisfies concentration-based and dose-based RGs as defined in the SLDS ROD (USACE, 1998a).

Where multiple radiological contaminants are present, the concentration-based soil RGs are expressed and evaluated using a "unity rule". The result of a unity rule calculation is referred to as a SOR. An SOR greater than or equal to 1.0 reflects a soil sample that exceeds the RGs.

The SOR_N calculations for surface (upper 0.15 m or 0.5 ft) and subsurface (below 0.15 m or 0.5 ft) soils are provided in the expressions below.

$$SOR_{N\text{-less than 0.15 m}} = \frac{(\text{greater of Th} - 230_N \text{ or Ra - } 226_N)}{5 \text{ pCi/g}} + \frac{(\text{greater of Th} - 232_N \text{ or Ra} - 228_N)}{5 \text{ pCi/g}} + \frac{\text{U - } 238_N}{50 \text{ pCi/g}}$$

$$SOR_{N\text{-greater than 0.15 m}} = \frac{(\text{greater of Th} - 230_N \text{ or Ra - } 226_N)}{15 \text{ pCi/g}} + \frac{(\text{greater of Th} - 232_N \text{ or Ra} - 228_N)}{15 \text{ pCi/g}} + \frac{\text{U - } 238_N}{50 \text{ pCi/g}}$$

The subscript "N" in the SOR equations represents net concentration(s) above background. Background was determined using 32 samples collected near the SLDS. When at least one systematic sample within a SU has an SOR_N value greater than or equal to 1.0, the WRS statistical test is used to determine if the SU as a whole meets the concentration-based RG.

The ROD specifies ARARs that pertain to the SLDS. 40 CFR 192.12 (a) establishes clean-up standards for land and provides that remedial actions shall be conducted so as to provide a reasonable assurance that the concentration of radium-226 in land averaged over any area of 100 m^2 shall not exceed the background level by more than 5 pCi/g averaged over the first 15 cm of soil below the surface and 15 pCi/g averaged over 15 cm thick layers of soil more than 15 cm below the surface.

The ROD specifies 10 CFR 20 Subpart E as an ARAR. 10 CFR 20 Subpart E provides standards for determining the extent to which land area must be remediated before decommissioning of a site can be considered complete and the license terminated. The standard states that the residual dose for unrestricted use should not exceed 25 mrem/yr total effective dose equivalent (TEDE) and that the as low as reasonably achievable (ALARA) principle is applied.

Administrative limits for DT-29 consolidated materials can be found in the FSSP and were adopted from the American National Standard ANSI/HPS N13.12 – 1999, *Surface and Volume Radioactivity Standards for Clearance* (ANSI, 1999). The ANSI standard provides surface activity criteria that are protective of the public health and the environment for clearance of items and materials under unrestricted use conditions. The consolidated materials measurement results were compared to the surface activity guideline of 600 disintegrations/minute (dpm)/100 square centimeters (cm^2) total alpha and 6,000 dpm/100 cm^2 total beta radioactivity.

A DQA is a scientific and statistical evaluation that determines if property 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 guidance from the EPA's *Guidance for Data Quality Assessment, Practical Methods for Data Analysis* (USEPA, 2000). The five steps in the DQA process are repeated below.

1. Review the final status survey design, including DQOs.
2. Conduct a preliminary data review.
3. Select a statistical test.
4. Verify the assumptions of the statistical test.
5. Draw conclusions from the data.

Each step in the DQA is discussed in the subsequent report sections. The DQA demonstrates that DT-29 SUs satisfied concentration-based RGs, dose and risk-based RGs, and statistical tests as outlined in the FSSP and supports releasing each SU without restriction.

C.2 FINAL STATUS SURVEY UNITS

In accordance with MARSSIM guidance, DT-29 was divided into two Class 1 SUs. The SUs are described in Table C-1.

Table C-1. SU Descriptions

SU	Class	Area (square meters)	Description
DT-29 SU-1	1	303	Surface and Subsurface Soils
DT-29 SU-2	1	87	Consolidated Material Surfaces

SU-1 for DT-29 consisted of approximately 30 m^2 of soil that was exposed during excavation and approximately 273 m^2 of unexcavated soil covered by asphalt surrounding the excavation area. The DT-29 SU-1 consisted of remediated (i.e., excavated) and unremediated land areas as shown in Attachment C-1, Figure C-1-2. Excavation of soils in excess of the RGs occurred in SU-1. The excavation was backfilled with USACE approved off-site borrow material.

SU-2 consisted of consolidated material (i.e., concrete pad) that was uncovered during the excavation of soils and left in place. The total area of SU-2 is approximately 87 m^2 as shown in Attachment C-1, Figure C-1-2.

C.3 FINAL STATUS SURVEY MEASUREMENTS

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

1. Surface gamma scans of land areas to identify locations within the property that were above the investigation level.
2. Biased samples to investigate areas identified during the gamma walkover scan.

3. Systematic samples to obtain the average radionuclide concentration across SU-1 to the prescribed depth.
4. Surface alpha and beta radioactivity scans on potentially impacted consolidated material surfaces (i.e., SU-2).
5. Biased total fixed point alpha and beta measurements to investigate any areas identified during the scan that were above the investigation level.
6. Systematic fixed point measurements of total alpha and total beta activity.

All of the measurements obtained, excluding those that were excavated during the RA, were used to evaluate the property against the RGs. Areas that contained residual radioactivity above RGs were remediated. A preferential pathway evaluation was performed and a determination was made that no preferential pathways samples were required.

In addition to the systematic samples needed to perform MARSSIM statistical tests, subsurface samples were collected in an effort to confirm that no unexpected subsurface contamination was present. These are referred to as "subsurface samples" in this report. Guidance on the collection of subsurface samples is contained within the FSSP. Data from biased and subsurface samples was not included in MARSSIM statistical tests, but was included in evaluations of residual dose and risk.

C.3.1 Surface Soil Gamma Scans

Sodium iodide (NaI) radiation detection instruments were used for the gamma radiation scans (i.e., gamma walkover surveys) to detect areas of elevated gamma radioactivity. Areas of elevated activity detected during the gamma walkover survey were sampled to determine if contamination existed at levels greater than the concentration-based RGs. Results from the gamma walkover survey and sampling provided information to delineate the excavation areas. During excavation gamma walkover surveys were used to detect areas of elevated gamma radioactivity.

When SU-1 was ready for final status survey, a gamma walkover survey was performed and documented prior to the collection of confirmation samples as shown in Attachment 7 Figures C-7-1 and C-7-2. Locations exceeding the investigation level established in the FSSP were evaluated and remediated if above the RG, as appropriate. If additional remediation was necessary the area was re-scanned to demonstrate the effectiveness of the remedial action.

C.3.2 Field Instrument Detection Sensitivity

The field radiation detection survey instruments (and their functional and performance specifications) used during the surveys are listed in Table C-2. Detection sensitivities were determined following the guidance of NUREG-1507 (NRC, 1998) and are derived in the FSSP. The sensitivities presented were derived using typical instrument parameters and are well below the RG for soil, with the exception of Th-230. Since Ra-226 and Th-230 are commingled, Th-230 is detected through the presence of Ra-226.

Table C-2. Radiological Field Survey Instruments

Description	Application	Detection Sensitivity[1]
Ludlum Model 2221 coupled with a Ludlum Model 44-10 (2-inch × 2-inch NaI gamma scintillation detector)	Gamma scans of all surfaces	Th-230 = 1120 pCi/g Ra-226 = 1.2 pCi/g U-natural = 40 pCi/g
Ludlum Model 2360 coupled with a Ludlum 43-89 (ZnS plastic scintillator).	Beta surface scan on concrete Beta static measurement on concrete Alpha surface scan on concrete Alpha static measurement on concrete	1780 dpm/100cm^2 at 2 inches per second 1111 dpm/100cm^2 342 dpm/100cm^2 at 2 inches per second 314 dpm/100cm^2

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

C.3.3 Soil Samples

Biased soil samples were collected at locations that exhibited an elevated count rate during gamma walkover survey (see Figure C-1-2). The results of biased samples, unless excavated during the RA, were included in residual dose and risk calculations.

Final status survey soil samples were collected using a random-start systematic grid. The number and location of samples collected in the SU were derived using MARSSIM guidance as described in the FSSP. The final status survey typically incorporated systematic collection of soil samples in SU-1 on the surface and at depth intervals of 18- to 24-inches or 24- to 30-inches. Sample borings at systematic sample locations were scanned to verify that subsurface pockets of contamination did not exist per the FSSP (USACE, 2000b). Soil samples were collected at 18- to 24-inch or 24- to 30-inches depth intervals unless scanning indicated elevated contamination levels in other locations of the boring. In general, one surface sample and one subsurface sample were collected at each systematic location. If soil contamination in excess of the subsurface RG was identified, further investigation and/or remediation was conducted, as appropriate, to achieve compliance with ROD RGs. The results of these samples were also included in residual dose and risk calculations. The sampling included the following listed elements:

- In SU-1, a sample was collected from an interval within the upper 6 inches of soil at all systematic sampling locations. Many samples were collected in unexcavated areas below the ground cover material (i.e., asphalt and gravel) and therefore, were subject to the subsurface evaluation criteria (i.e., 15/15/50) if the cover material was greater than six inches in thickness.. The remaining systematic samples were collected within the excavation areas. Systematic sampling depths were generally extended to collect additional samples at 18- to 24-inch or 24- to 30-inches. One hundred percent of the Class 1 samples collected in the top 30-inch interval were subjected to laboratory analysis. The land area SU-1 sampling results were compared to ROD RGs as discussed in Sections C.5 and C.7.
- Prior to final status survey of SU-1, a professional geologist inspected the SU for potential migration pathways. The preferential pathway evaluation indicated that preferential pathway samples were not required for SU-1.

- Biased samples were collected in SU-1 areas that had elevated activity as indicated during the gamma walkover surveys. Biased samples were typically collected within the upper 6 inches of the surface soil. Each of the biased samples collected were subjected to laboratory analysis.

C.3.4 Alpha and Beta Activity Scan and Fixed Point Measurements

Alpha and beta activity measurements were performed on SU-2 consolidated materials with Ludlum 43-89 scintillation detection instrumentation. When SU-1 soil areas were excavated and SU-2 consolidated materials slated to remain in-place were exposed, a 100% alpha and beta scan survey was performed on the accessible surface. The exposed surface of the consolidated materials (e.g., concrete pad) was divided into approximate 1-m^2 areas. One total alpha and one total beta activity fixed-point measurement were recorded for approximately every 3.5 m^2 area of the consolidated material. Fixed point measurements were also recorded at elevated locations identified during the scan survey. The measurements were used to demonstrate that the SU satisfied the RGs. Daily field performance checks were conducted in accordance with instrument use procedures (SAIC, 2003). 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.

C.4 REVIEW FINAL STATUS SURVEY DESIGN

C.4.1 Final Status Survey Design for Soil (SU-1)

The FSSP specifies the design for the final status survey. The review of site data estimated that approximately 7 surface soil samples per SU were needed for the WRS test. However, additional samples were collected on a systematic grid to account for the reduced scan sensitivity in asphalt covered areas.

Once property-specific final status survey data (i.e., surface systematic sample data) were available, the calculation of the number of samples needed to support the WRS test was repeated for SU-1 to confirm that enough samples had been collected. Using the surface systematic sample data standard deviations for Ra-226, U-238, Th-230, and Th-232 from the SU data summary in Attachment C-4, the number of samples required for the WRS test for SU-1 was calculated and is presented below.

The relative shift (Δ/σ) was calculated using values for the SOR_N, lower bound of the gray region (LBGR), and standard deviation (σ). The SOR_N was set to 1.0, so the LBGR = SOR_N /2 = 0.5. The value for Δ was therefore, SOR_N - LBGR = (1.0) - (0.5) = 0.5. The σ of the systematic samples SOR_N values is 0.26.

Using this value and a Δ = 0.5, the Δ/σ for the SU-1 was calculated to be 1.92. This value is within the MARSSIM recommended range of 1 to 3 for Δ/σ. From Table 5.3 in MARSSIM and given 0.05 for the Type I error and 0.20 for the Type II error, the minimum number of surface systematic samples required for SU-1 was estimated to be 8. Twenty-one surface systematic samples were actually collected from DT-29 SU-1. This demonstrates that an adequate number of samples were collected to satisfy the WRS statistical test in SU-1.

Table C-3 below list the actual number of systematic samples collected and the minimum number of systematic samples required for each SU.

Table C-3. Number of Samples Required

SU [1]	Class	Minimum Systematic Samples Required	Number of Systematic Samples Collected
SU-1	1	8	21
SU-2	1	7	25

[1] SUs are described in Table C-1.

C.4.2 Final Status Survey Design for Consolidated Materials (SU-2)

The number of samples needed to complete the Sign Test for the concrete structures in SU-2 was determined using the standard deviation for alpha fixed point measurements. The standard deviation for alpha fixed point measurements was 66 (see Table C-8-4).

Using a σ value of 66 and a $\Delta = 300$, the relative shift (Δ/σ) for the survey unit was calculated to be 4.6. This value falls outside the MARSSIM recommended range of 1 to 3 for Δ/σ, therefore, per MARSSIM guidance the LBGR should be adjusted to achieve the recommended range. If the LBGR is raised to 400, then Δ/σ is (600 – 400)/66 or 3. From Table 5.5 and equation 5-2 in MARSSIM and given 0.05 for the Type I error and 0.20 for the Type II error, the minimum number of systematic measurements required for the survey unit was estimated to be 7. Twenty-five systematic measurements were actually collected from SU-2. This demonstrates that an adequate number of measurements were collected to satisfy the Sign Test in SU-2.

C.5 DATA EVALUATION

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

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

Property data was used to estimate the number of data points needed for statistical testing (i.e., WRS test). Actual data collected from DT-29 and the 32 samples from the reference background areas located to the north and south of the SLDS were utilized to evaluate the final status survey results.

C.5.1 Data Quality Indicators

Final status survey sample data were reviewed for precision, accuracy, representativeness, completeness, and comparability. These indicators are summarized in Section 4.6 of the FSSP and are presented in detail in the QA section of the Sampling and Analysis Guide (SAG) (USACE, 2000).

Precision and accuracy are determined by the analysis of field duplicate samples and split samples. Precision is measured by comparing the analytical results of the field duplicates, which are samples collected at the same location as the field sample they duplicate and analyzed in the same laboratory. Accuracy is measured by comparing the results of split samples, which are aliquots of field samples analyzed by a separate laboratory. DT-29 split samples were analyzed by Severn-Trent Laboratories and the USACE-St. Louis District laboratory at the HISS.

The DQOs established in the FSSP require that 5% of the total number of samples be duplicated and split with another laboratory. A total of four splits and five duplicates were obtained from the 43 systematic and subsurface samples collected during the final status survey. This achieved the DQO of 5% for duplicate and split samples.

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

Representativeness, comparability, and completeness are subjective decisions based on the sampling strategy and the ability of the data to meet requirements. Data were collected according to the FSSP using a MARSSIM random-start systematic grid sampling technique to ensure representativeness of the data to actual property conditions. The data were collected and analyzed according to the methods presented in the SAG (USACE, 2000). The data were verified and validated according to the QAPP (USACE, 2000). The detailed results of the QC analysis for SLDS DT-29 data are provided in Attachment C-2 QCSR.

C.5.2 Comparison to Concentration-Based RGs

The RGs for SLDS DT-29 are stated in Section C.1. Each survey unit was evaluated to determine that the average SOR_N over the entire SU did not exceed 1.0 and that the aerial average Ra-226 concentration over any 100 m^2 area did not exceed 15 pCi/g in any 15 cm (6 inch) thick layer of soil more than 15 cm below the surface and did not exceed 5 pCi/g in surface soil layer. Results from the systematic samples must also satisfy the WRS test.

The mean surface systematic sample SOR_N used for the MARSSIM evaluation for SU-1 was approximately 0.2, well below 1.0. The data are summarized in Attachment C-4.

DT-29 contained three sample results having an SOR_N greater than 1.0. Each of these areas complies with aerial average stated in the ARAR-based RG. The evaluation consisted of obtaining an area weighted average SOR_N of adjacent samples that fell within the surrounding 100 m^2 (See Attachment C-5). The area that a biased sample represents in Attachment 5 may have been increased in order to determine a conservative 100 m^2 weighted average SOR value. All sample results including those areas that are elevated are incorporated into the residual dose and risk assessment (See Section C.7).

C.5.3 Statistical Test

Statistical tests (e.g., WRS and sign test) are designed to determine whether or not the level of residual activity uniformly distributed throughout the survey unit exceeds the release criteria. Because the radionuclide contaminant of concern is present in background, the WRS test is selected as the appropriate statistical test for SUs consisting of soil. Per MARSSIM the completion of the WRS test is only required in SUs in which the highest gross SU measurement minus the lowest reference area measurement results in an SOR_G value greater than 1.0. Based on the above criteria SU-1 requires the WRS test. SU-1 passed the WRS test and results are provided in Attachment C-6.

Per MARSSIM, for situations where the contaminant is not present in background or is present at such a small fraction of the criteria, as to be considered insignificant, a background reference area is not necessary. In this situation the sign test replaces the WRS test. The sign test was used to assess SU-2 (i.e., consolidated materials) surface activity measurements because the background alpha and beta activity measured on consolidated material in SU-2 is insignificant as compared to the guideline and therefore, no reference area measurements were required for the consolidated materials. See Section C.6 for additional information on the sign test for the consolidated materials.

C.5.4 Comparison to the Reference Area and Evaluation of Parameters

Sample results for systematic final status survey soil sample data, biased soil sample data, and subsurface soil sample data are listed in Attachment C-3. Reference area and Final Status Survey data are summarized in Attachment C-4. The data shows that U-238, Th-230, and Ra-226 are the primary contaminants of concern with U-238 having slightly greater concentrations than Ra-226 and Th-230 concentrations averaged over the each SU. Results of other radionuclides are generally within the range of background and contribute negligibly to the SOR_N calculations.

The reported radionuclide concentrations from the laboratory were used in this report even if below the minimum detectable activity (MDA). MARSSIM recommends that analytical methods should be capable of measuring levels at 10-50% of the established concentration-based RG. MDAs for U-238, Th-230, Th-232, and Ra-226 achieved levels below 50% of the RG.

The comparison of final status survey data to reference area data and RGs confirms that data are sufficient to support the release of the DT-29 accessible areas.

C.6 CONSOLIDATED MATERIALS EVALUATION

The fixed-point measurements on consolidated materials were compared to guidelines contained in ANSI/HPS N13.12 – 1999. The guidelines for consolidated materials are 600 dpm/100cm^2 total alpha activity and 6000 dpm/ 100cm^2 total beta activity as discussed in Section C.1. SU-2 consisted of consolidated materials. The average of the surface measurements for SU-2 was below the guidelines. The results of individual measurements are listed in Attachment C-8, Table C-8-1.

Total surface activity measurements that indicated activity greater than the guidelines were subject to further evaluation. Each measurement above the guideline was averaged with the surrounding 1 m^2 area to verify that the average of the 1 m^2 area did not exceed the guidelines. The results of the elevated measurements and the average of the surrounding 1 m^2 area are presented in Attachment C-8, Table C-8-3.

Although the final status surface activity measurements satisfied the guidelines, a sign test was also performed as an additional verification that the SU measurements were below the guidelines. The results of the sign test are presented in Attachment C-8, Table C-8-2.

C.7 RESIDUAL DOSE AND RISK ASSESSMENT

A conservative site-specific post-remedial action residual dose and risk assessment was performed for the Class 1 areas by using the final status survey data for DT-29 of the FUSRAP

SLDS. The dose and risk assessment was performed in accordance with the SLDS ROD to confirm that the site had been protectively remediated and to verify that the selected remedy had met the response action objectives regarding dose and risk criteria so that the site could be released for use without any radiological restriction. The ROD for the SLDS established the CERCLA target risk range as the risk criteria and the 10 CFR 20 Subpart E dose limit of 25 mrem/yr as the dose criteria for the SLDS (USACE 1998b). 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 1E-04. A specific risk estimate around 10^{-4} may be considered acceptable if justified based on site-specific conditions" (USEPA 1997a).

RESRAD version 6.22 was used during the dose and risk assessment for DT-29 to calculate dose and risk to the potential receptors. RESRAD is a computer code developed at Argonne National Laboratory for the DOE to determine site-specific residual radiation guidelines and dose to a future hypothetical on-site receptor at sites that are contaminated with residual radioactive materials. The use of RESRAD codes for modeling dose and risk 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 Uranium Mill Tailings Radiation Control Act (UMTRCA) soil criteria and in its rulemaking for cleanup of sites contaminated with radioactivity.
- Seven U.S. Cabinet-level agencies including EPA, DOE, NRC, and DOD, functioning as the Interagency Steering Committee on Radiation Standards formally accepted RESRAD-BIOTA.
- The EPA was also a signatory to the SLDS ROD that used RESRAD and is a participant in many other CERCLA actions involving RESRAD.

Residual dose and risk assessments in the SLDS FS were performed using RESRAD version 5.62. RESRAD 5.62 incorporates the HEAST 1995 morbidity slope factors, whereas RESRAD 6.22 incorporates FGR 13 morbidity slope factors. The newer FGR 13 slope factors are pathway specific and are more conservative for the SLDS COCs.

In accordance with 40 CFR 192, Subpart A, control of residual radioactive materials from inactive uranium processing sites shall be designed to be effective for up to 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. Therefore dose associated with the control (remedial action) is assessed for a 1000 year period. Risk is only required to be assessed for a 30-year period under the residential land use scenario in accordance with CERCLA. However, risk in this report was assessed for a 1000 year period as well as dose.

Dose and risk scenarios for the SLDS ROD are based on the industrial/utility worker and industrial/construction worker exposure scenarios defined in the SLDS FS (USACE, 1998b). The assessments for SLDS DT-29 were performed for each of these scenarios, and an additional onsite residential scenario was considered at the request of regulators. Each receptor scenario is summarized as follows:

1. Industrial Worker: The industrial worker is modeled as a typical site worker who spends most of their time indoors. The worker is at the site 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 or late daily departure.

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

3. Onsite Residential Receptor: The onsite residential receptor is modeled as a potential future receptor in case the current land use for DT-29 areas changes to residential. The residential receptor is assumed to live onsite for 350 days per year for 30 years (EPA, 2000b). The resident is assumed to spend 16.4 hours indoors and 2.0 hours outdoors each day (EPA 1997b). Among outdoor activities, the resident is assumed to spend 0.2 hours each day for gardening.

The input parameters selected for the utility and industrial worker scenarios are those defined in the SLDS FS (USACE, 1998b). The input parameters selected for the onsite residential receptor scenario are those defined for the onsite residential receptor in the *Post-Remedial Action Report for the Accessible Soils Within the St. Louis Downtown Site Plant 2 Property* (USACE, 2002a). Input parameters for the hydrological data were selected from the BRA and SLDS FS. The non-default RESRAD input parameters for the three receptor scenarios are presented below in Table C-4.

TABLE C-4. RESRAD Input Parameters For Dose And Risk Assessments

Category	Parameter	Values		
Physical Parameters	Area of Contaminated Zone (m^2)	SU-1	303	
		Site	303	
	Thickness of the Contaminated Zone (m)	2		
Cover Parameters	Cover Depth	0		
	Density of the Cover Material	Not Applicable		
	Cover Erosion Rate	Not Applicable		
Hydrological Data for Contaminated Zone	Density of Contaminated Zone (g/cm^3)	1.28 (Clay Loam)		
	Contaminated zone Total Porosity	0.42 (Clay Soil)		
	Contaminated zone Field Capacity	0.36		
	Contaminated zone Hydraulic Conductivity (m/yr)	3.048		
	Contaminated zone b parameter	10.4		
	Wind Speed (m/s)	4.17		
	Precipitation (m/yr)	0.92		
	Irrigation (m/yr)	0		
	Run off Coefficient	0.8 (Built-Up Area)		
	Contaminated zone Erosion Rate	0.00006		
Exposure Parameters		**Onsite Resident**	**Utility Worker**	**Industrial Worker**
	Inhalation Rate (m^3/yr)	8400	10,550	10,550
	Mass Loading for Inhalation (g/m^3)	5.9E-06	0.0002	0.0002
	Exposure Duration (yr)	30	1	25
	Indoor Dust Filtration Factor	0.5	0.5	0.5
	Indoor Time Fraction	0.655	0	0.1969
	Outdoor Time Fraction	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

The exposure pathways applicable to the dose and risk assessment for all scenarios are external gamma, soil ingestion, and inhalation of particulates. The plant ingestion pathway is also considered for the on-site resident. Since groundwater is not a potential source of drinking water for SLDS, the drinking water pathway was not considered as a potential pathway for the site.

Dose and risk for DT-29 is determined by developing a source term for SU-1, 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). The following section summarizes the process for calculating EPCs for each COC at each SU.

DT-29 includes one soil SU. DT-29 SU-1 includes both systematic and biased samples. In the SU, a representative area equal to the SU area divided by the number of systematic sampling locations was established for each systematic sampling location. Systematic sample locations are those locations where samples were taken to perform the MARSSIM statistical tests. Then an area-weighted average concentration for each radionuclide COC was determined for each representative area based on the area and concentration results of both systematic and biased samples within that representative area by using the following equation.

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

Where;

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

Representative area, area-weighted average COC concentrations were used to determine the UCL_{95} (95% Upper Confidence Limit of the mean) value for SU-1. Determination of the UCL_{95} for each radionuclide depends upon the distribution of the sampling results. EPA's designed software ProUCL (version 3.0) was used during the determination of distribution of sampling results. The software determines the UCL_{95} based on the distribution. The EPCs for the SU are determined by subtracting the average background concentration from the smaller of the UCL_{95} or the maximum detection concentration. Since DT-29 has only one soil SU, radionuclides EPC for thc site are the same as that for the SU. Table C-5 presents the EPCs for the survey unit.

Table C-5. Exposure Point Concentrations for the Survey Unit

Sites	Statistic	Radionuclide Concentrations (pCi/g)								
		Ra-226	**Th-230**	**U-238**	**U-235**	**Th-232**	**Ra-228**	**Th-228**	**Ac-227**	**Pa-231**
DT-29 SU-1	Background	2.78	1.94	1.44	0.09	1.09	0.95	1.16	0.14	0.89
	Mean	2.07	2.83	11.69	0.67	0.83	0.74	1.12	0.46	0.34
	Maximum	7.76	13.02	61.70	3.66	1.69	1.73	2.28	7.16	5.52
	Distribution[1]	N	X	X	X	N	N	G	X	G
	UCL-95	2.42	2.89	11.92	0.70	0.90	0.84	1.25	1.01	0.26
	EPC	**0.00**	**0.95**	**10.48**	**0.61**	**0.00**	**0.00**	**0.09**	**0.87**	**0.00**

[1] N=Normal; G = Gamma; X = Non-parametric

Table C-6 summarizes the highest radiological dose and risk in a 1000 year period to each of the three receptors from exposure to the residual radionuclides present at DT-29.

Table C-6. Highest Dose and Risk for Entire Site to Different Receptors

Industrial Worker		Utility Worker		Onsite Resident	
Dose (mrem/yr)	Risk	Dose (mrem/yr)	Risk	Dose (mrem/yr)	Risk
1	1E-05	0.1	3E-08	3	5E-05

The RESRAD results indicate that the onsite residential receptor received the highest dose and risk among the three receptors. The highest residential dose and risk for DT-29 were 3 mrem/yr and 5E-05, respectively. The dose for all receptors is below 25 mrem/yr. The risk for the two scenarios required by the ROD (Industrial and Utility Worker) and the Onsite Resident were within the CERCLA risk range. The actual property risk for all scenarios would be lower than the calculated risk since:

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

In summary, for DT-29 (Midtown Garage) areas, the results of the residual dose assessments show that the maximum residual dose for both current and future receptor scenarios is less than the dose criteria (25 mrem/yr), established by 10 CFR Part 20, Subpart E. The results of the residual risk assessment show that the maximum risk for both current and future receptors is within the CERCLA target risk range. Therefore, based on the results of dose and risk assessments, it can be concluded that residual dose and risk at DT-29 are protective for all potential receptor scenarios and the site can be released for use without any land use restrictions.

EPC calculations (including Pro-UCL output files) and RESRAD output files for all modeled scenarios are on file as part of the St. Louis FUSRAP records/files for the SLDS.

C.8 CONCLUSIONS

The USACE and EPA determined that Selective Excavation and Disposal was the most appropriate remedy for accessible soil at the SLDS based upon consideration of the requirements of CERCLA, a detailed analysis of the alternatives, and extensive public participation and comment. The remedy for DT-29 addressed soil contaminated with radioactivity related to MED/AEC uranium manufacturing and processing at SLDS.

Comparison to ROD Criteria

The RAOs for DT-29 apply to areas affected by the MED/AEC uranium manufacturing and processing activities. This section lists (i.e., bullet/italicized items) each ROD remedial action objective (i.e., RG) and describes how the USACE is demonstrating compliance with the RG.

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

The 5/5/50 RG was used for comparison against the data collected from surface soils in the first 0.5 ft below original grade. The 15/15/50 subsurface RG was used for comparison against the data collected in accessible soils below 0.5 feet. In SU-1, soil samples were collected at the soil surface (below cover) and at 18-24 inch or at 24-30 inch intervals below ground surface. All DT-29 SUs have SOR_N values of less than 1.0 when averaged over the SU. Therefore, the SU data demonstrates compliance with this ROD RG. Details on the SOR_N results can be found in Section C.5.2.

In addition, the 40 CFR 192 ARAR for surface/subsurface soils (5/15 pCi/g Ra-226 averaged over 100 m^2) was used for comparison against the data collected in accessible soils in Class 1 SUs. The aerial density of samples collected in SU-1 met the 100 m^2 aerial requirement and the average Ra-226 concentration was less than the RG in SU-1. Details on the 100 m^2 aerial average results can be found in Section C.5.2 of this report.

- *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).*

  Per the ROD deep soil RGs do not apply to VPs.

- *For arsenic and cadmium:*

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

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

  Per the ROD arsenic and cadmium requirements are not applicable to DT-29.

- *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 NCP (USACE, 1998a).*

  This statement in the ROD is true for all DT-29 SUs. The systematic sample SOR_G for all SUs (the raw data including background) is also less than 1.0 when averaged across the SU. SOR_G calculations for each SU can be found in Attachment C-4. Per the ROD chemical RGs are not applicable to Vicinity Property DT-29.

- *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. Class 1 survey unit sizes were selected to be 2,000 m^2 ± 10 % as recommended by MARSSIM. Details on SU areas can be found in Section C.2 of this report.

In survey units that had individual systematic samples with the highest gross SU measurement minus the lowest reference area measurement resulting in an SOR greater than 1.0, the survey unit was subjected to WRS statistical testing to indicate that the activity in the survey unit is less than the RGs. SU-1 passed the WRS test. Details on the WRS test can be found in Section C.5.3 of this report.

Final status survey data were evaluated to demonstrate that enough samples were collected in each survey unit. All DT-29 SUs have enough samples to satisfy statistical testing requirements. Details on the required number of samples to satisfy statistical testing can be found in Section C.4 of this report.

Per the ROD chemical analysis is not required for DT-29.

Data quality indicators were reviewed for precision, accuracy, representativeness, completeness, and comparability. All data quality indicators are considered acceptable and the data are useable for their intended purpose. Details on DQIs can be found in Section C.5.1 of 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 outlined in the ROD. In addition, regulators requested that the USACE develop an on-site residential scenario in case the current land use for DT-29 areas changed from industrial to residential. The residual dose and risk calculated for DT-29 is less than or equal to 3 mrem/yr and 5 E-05, respectively for all modeled scenarios (i.e., Industrial Worker, Utility Worker, and On-site Resident) without regard to any cover material. The dose and risk from actual residual conditions at DT-29 are considered acceptable to release the accessible areas without restrictions. Details of the dose and risk assessment can be found in Section C.7 of this report.

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

  The dose and risk from actual residual conditions (without regard to cover materials) are considered acceptable to release DT-29 SUs without restrictions. There are no areas on DT-29 SUs where it is necessary to apply restrictions or institutional controls. Details of the dose and risk assessment can be found in Section C.7 of this report.

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

The dose and risk from actual residual conditions (without regard to cover materials) are acceptable to release DT-29 accessible areas without restrictions. Details of the dose and risk assessment can be found in Section C.7 of this report. There are no accessible areas at DT-29 where it is necessary to apply 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 ground water 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).*

  DT-29 does not have any 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. An Environmental Monitoring Guide for the St. Louis Sites (USACE, 1999) has been written and is currently being implemented by the USACE through Environmental Monitoring Implementation Plans for each fiscal year.

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

  DT-29 does not have any ground-water monitoring wells, however SLDS perimeter wells in the Mississippi Alluvial Aquifer are being monitored in accordance with the Environmental Monitoring Guide for the St. Louis Sites. The requirements in the guide are currently being implemented by the USACE through Environmental Monitoring Implementation Plans for each fiscal year. These requirements include perimeter well ground-water monitoring.

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

  Pa-231 and Ac-227 were included in the post-remedial action dose and risk assessments. The average Pa-231 and Ac-227 concentrations were less than 0.7 pCi/g in all SUs and therefore did not significantly affect residual dose or risk. Details of the dose and risk assessment can be found in Section C.7 of this report.

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

  There were no accessible sewers and drains on DT-29.

Additionally, fixed-point measurements on consolidated materials (i.e., SU-2) were compared to guidelines contained in ANSI/HPS N13.12 – 1999. The guidelines for consolidated materials are 600 dpm/100cm^2 total alpha activity and 6000 dpm/100cm^2 total beta activity as discussed in Section C.1. The average of the surface measurements for SU-2 was below the guidelines. The results of individual measurements are listed in Attachment C-8, Table C-8-1.

The residual radioactivity in accessible areas at DT-29 meets all requirements specified in the ROD. This conclusion is the result of comparison of ROD requirements and the residual site condition. The concentration based RGs for Th-230, Ra-226, Th-232, Ra-228, and U-238 are satisfied, noting that no SOR_N value exceeds the RG of 1.0 when averaged over the SU (the average SOR_N excluding background in Class 1 SUs was 0.18) and no Ra-226 concentration averaged over 100 m^2 exceeds 15 pCi/g. The dose-based ARAR from 10 CFR 20 Subpart E, "Radiological Criteria for License Termination" has been satisfied noting that the highest dose calculated is approximately 3 mrem/yr to an on-site resident using conservative exposure assumptions without regard to any cover material. The residual dose and risk calculated for DT-29 is less than or equal to 3 mrem/yr and 5 E-05, respectively for all modeled scenarios (i.e., Industrial Worker, Utility Worker, and On-site Resident) without regard to any cover material. SU-1 also satisfies the statistical requirements by passing the WRS test. Soil concentrations comply with 40 CFR 192 unrestricted release criteria. All DT-29 SUs are released without radiological restrictions in accordance with the ROD.

ATTACHMENT C-1
DT-29 FINAL STATUS SURVEY UNITS AND SOIL SAMPLING LOCATION FIGURES

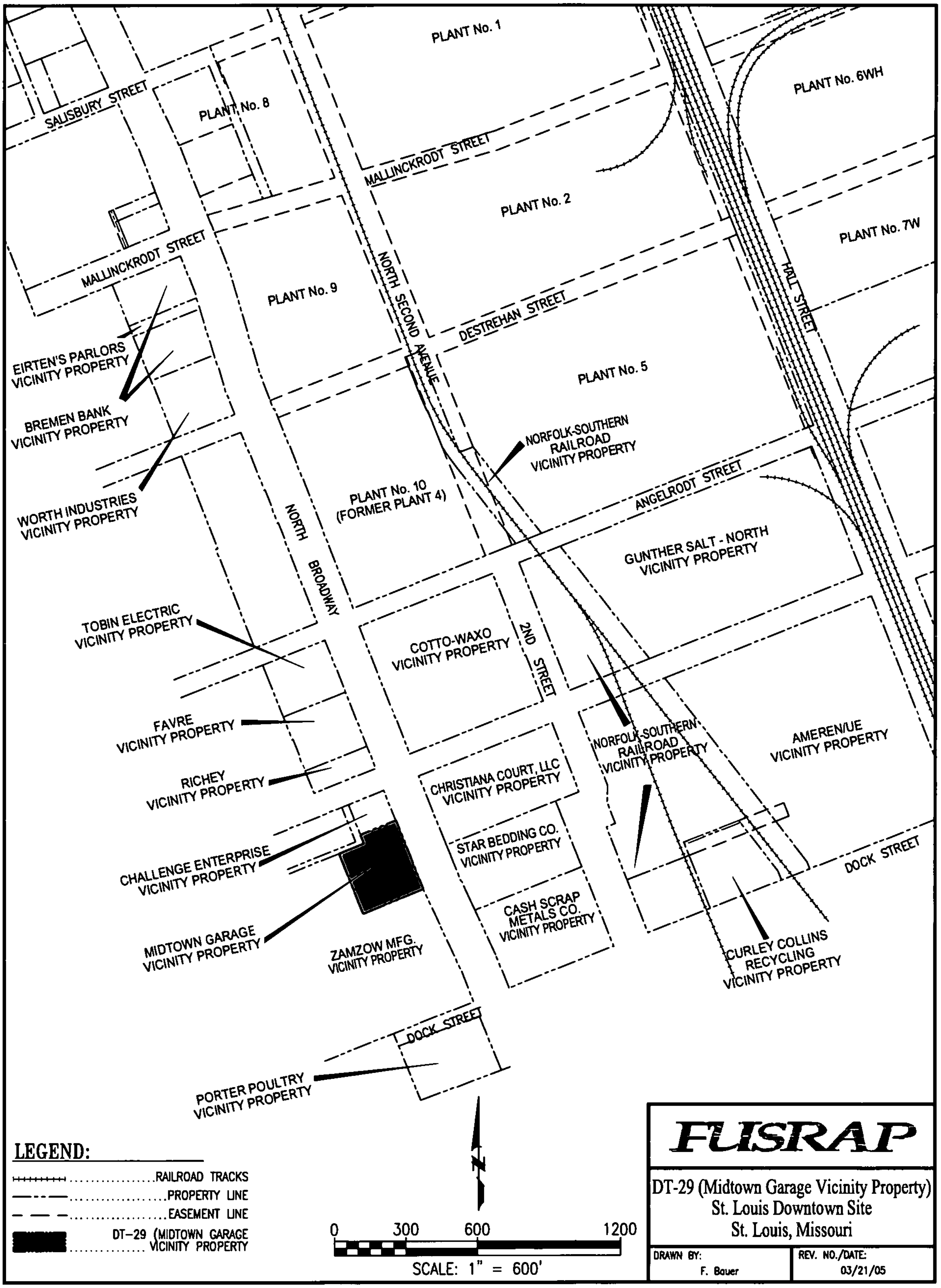

Figure C-1-1. Location Map for DT-29

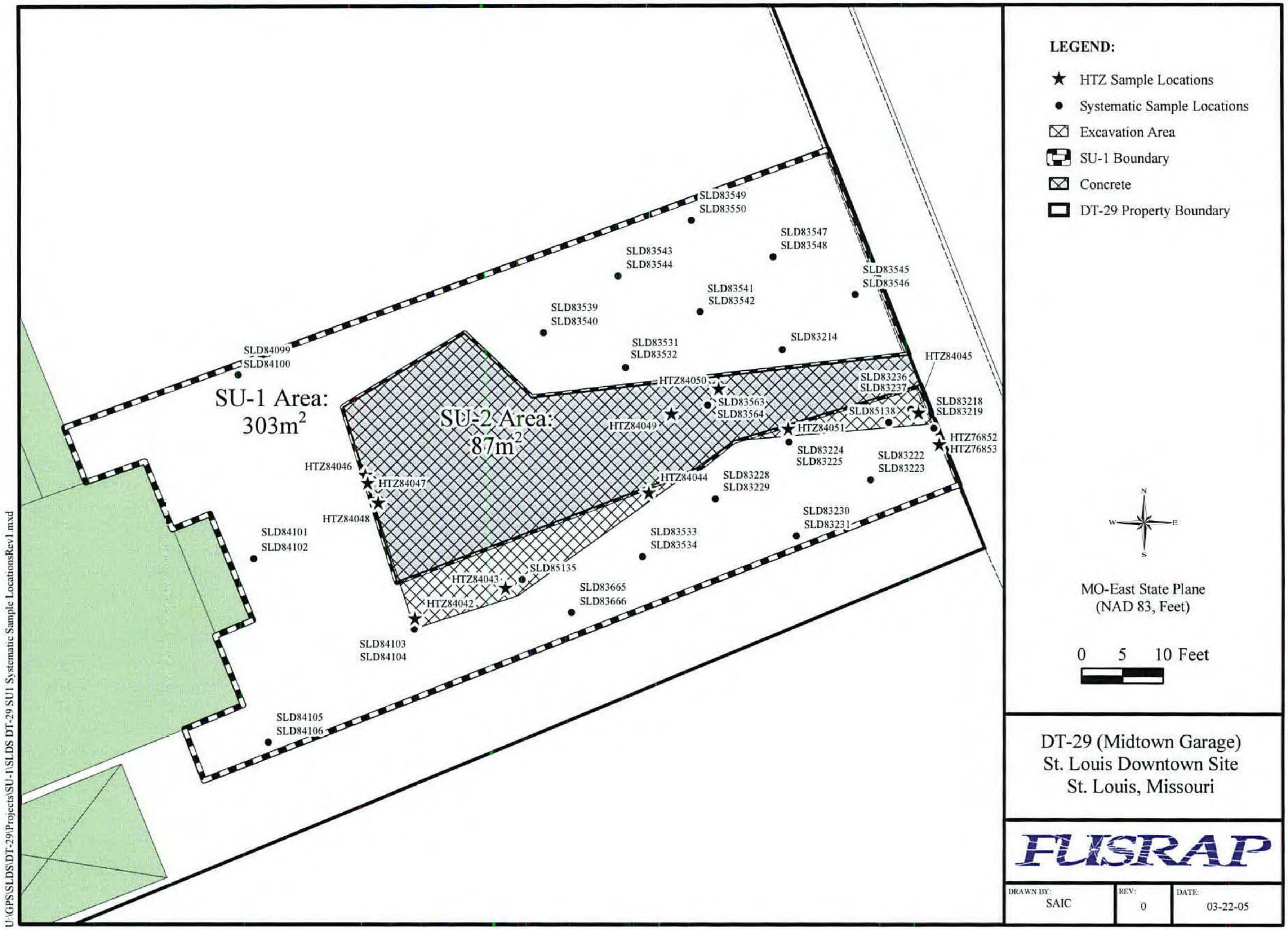

Figure C-1-2 DT-29 Survey Units and Sample Locations

ATTACHMENT C-2
DT-29 QUALITY CONTROL SUMMARY REPORT

DT-29 (Midtown Garage)
QUALITY CONTROL SUMMARY REPORT

C-2.1 INTRODUCTION

C-2.1.1 Project Description

Class 1 final status survey sampling was conducted for DT-29 at the SLDS. Sampling was conducted in accordance with MARSSIM protocols and the FSSP (USACE, 2002b).

C-2.1.2 Project Objectives

The intent of the final status survey was to evaluate whether each survey unit satisfies concentration-based and dose-based criteria as defined in the SLDS ROD.

C-2.1.3 Project Implementation

The sampling was conducted from March 2004 until October 2004. Radiological analyses were conducted by the onsite FUSRAP laboratory at the HISS with QA split samples being analyzed by Severn-Trent Laboratories.

C-2.1.4 Purpose of this Report

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

C-2.2 QUALITY ASSURANCE PROGRAM

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

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

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

a. laboratory case narratives
b. sample results
c. laboratory method blank results
d. laboratory control standard results
e. laboratory sample matrix spike recoveries
f. laboratory duplicate results
g. surrogate recoveries (VOCs, SVOCs, Pesticide/PCBs)
h. sample extraction dates
i. sample analysis dates

This information from the laboratory, along with field information, provides the basis for subsequent data evaluation relative to sensitivity, precision, accuracy, representativeness and completeness. These parameters have been presented in Section C-2.4.

C-2.3 DATA VALIDATION

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

C-2.3.1 Laboratory Data Validation

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

- *USACE Kansas City and St. Louis District Radionuclide Data Quality Evaluation Guidance for Alpha and Gamma Spectroscopy, December 17, 2002* (USACE, 2002b).
- SAIC Technical Support Contractor QA Technical Procedure (TP-DM-300-7) *Data Verification and Validation* (SAIC,2004).

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

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

Method Requirements
Requirements for methods: - Holding time information and methods requested - Discussion of laboratory analysis, including any laboratory problems *Radiochemical Analysis* - Sample results - Initial calibration - Efficiency check - Background determinations - Spike recovery results - Internal standard results (tracers or carriers) - Duplicate results - Self-absorption factor (α,β) - Cross-talk factor (α,β) - Laboratory control samples (LCS) - Run log

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

C-2.3.2 Definition of Data Qualifiers (Flags)

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

"=" Positive Result.

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

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

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

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

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

C-2.4 DATA EVALUATION

C-2.4.1 Accuracy

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

C-2.4.1.1 Radiological Parameters

99.3% of the individual sample chemical yields and LCS recoveries were within the ± 25% criteria for the verification samples, as stated in the SAG. Therefore, the data can be used for its intended purpose.

C-2.4.1.2 Inter-Laboratory Accuracy

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

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

Thc analytical accuracy (i.e., split precision) between the FUSRAP laboratory and the contract laboratory met the Final Status Survey goal of ensuring that 90% of DT-29 verification samples were within either the ±30% criteria for RPD or less than 1.96 for the NAD DQI (Tables C-2-1 and C-2-2). All samples are within control limits. Analytical results can be found in Tables C-2-5 and C-2-6.

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

Where: S = Parent Sample Result

D = Ficld Split Result

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

Where: S = Parent Sample Result

D = Field Split Result

U_S = Parent Sample Uncertainty

U_D = Field Split Uncertainty

Table C-2-1. Split Precision Among Alpha Spectroscopy Analyses

	Thorium-228		Thorium-230		Thorium-232	
Sample Name	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**
SLD83224/SLD83224-2	1.8%	N/A	10.8%	N/A	NC	NC
SLD83230/SLD83230-2	N/A	0.53	NC	NC	NC	NC
SLD83543/SLD83543-2	N/A	0.51	NC	NC	NC	NC
SLD84106/SLD84106-2	N/A	1.10	NC	NC	NC	NC
SLD85135/SLD85135-2	*	*	*	*	*	*

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

Table C-2-2. Split Precision Among Gamma Spectroscopy Analyses

	Actinium-227		Americium-241		Cesium-137		Potassium-40		Protactinium-231		Radium-226		Radium-228		Uranium-235		Uranium-238	
Sample Name	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**
SLD83224/SLD83224-2	NC	NC	NC	NC	NC	NC	25.5%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD83230/SLD83230-2	NC	NC	NC	NC	NC	NC	1.5%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD83543/SLD83543-2	NC	NC	NC	NC	NC	NC	27.1%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD84106/SLD84106-2	NC	NC	NC	NC	NC	NC	11.8%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD85135/SLD85135-2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

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

C-2.4.2 Precision

C-2.4.2.1 Laboratory Precision

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

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

C-2.4.2.2 Field Precision

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

For the five field duplicate samples taken for the verification activities, the NAD and RPD values indicated good precision for the data. All samples were within control limits. Analytical results can be found in tables C-2-5 and C-2-6.

C-2.4.3 Sensitivity

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

C-2.4.4 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.

Table C-2-3. Field Duplicate Precision Among Alpha Spectroscopy Analyses

	Thorium-228		Thorium-230		Thorium-232	
Sample Name	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**
SLD83224/SLD83224-1	19.5%	N/A	1.9%	N/A	NC	NC
SLD83230/SLD83230-1	N/A	0.70	NC	NC	NC	NC
SLD83543/SLD83543-1	N/A	0.35	NC	NC	NC	NC
SLD84106/SLD84106-1	12.6%	N/A	NC	NC	NC	NC
SLD85135/SLD85135-1	18.0%	N/A	NC	NC	NC	NC

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

Table C-2-4. Field Duplicate Precision Among Gamma Spectroscopy Analyses

	Actinium-227		Americium-241		Cesium-137		Potassium-40		Protactinium-231		Radium-226		Radium-228		Uranium-235		Uranium-238	
Sample Name	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**	**RPD**	**NAD**
SLD83224/SLD83224-1	NC	NC	NC	NC	NC	NC	12.9%	N/A	NC	NC	NC	NC	NC	NC	N/A	0.23	NC	NC
SLD83230/SLD83230-1	NC	NC	NC	NC	NC	NC	8.4%	N/A	NC	NC	NC	NC	NC	NC	N/A	1.17	NC	NC
SLD83543/SLD83543-1	NC	NC	NC	NC	N/A	0.72	16.8%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD84106/SLD84106-1	NC	NC	NC	NC	NC	NC	22.1%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
SLD85135/SLD85135-1	NC	NC	NC	NC	NC	NC	6.8%	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

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

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

Table C-2-6 compares sample results from the Field Duplicate and Split Samples to the associated Parent Sample. Results from the Split Sample are corrected in this table by a factor of 1.5 for comparability to the Parent Sample and Field Duplicate. This correction factor represents the ingrowth necessary to conservatively report Ra-226, as reported by the St. Louis FUSRAP Radiological Laboratory.

C-2.4.5 Completeness

Usable data are defined as those data, which pass individual scrutiny during the verification and validation process and are accepted for unrestricted use. The data quality objective of achieving 90% completeness, as defined in the FSSP (USACE, 2002b) was satisfied with the project producing valid results for 100% of the sample analyses performed and successfully collected.

A total of 43 systematic and subsurface verification and 12 biased soil samples were collected with approximately 495 discrete analyses (i.e., nine analytes) being obtained, reviewed, and integrated into the assessment. The project produced acceptable results for 100% of the sample analyses performed.

C-2.5 DATA QUALITY ASSESSMENT SUMMARY

The overall quality of the DT-29 PRAR 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.

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

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

Table C-2-5. Alpha Spec Results for Parent Samples and the Associated Field Duplicates and Field Splits

Sample Name	Thorium-228	Thorium-230	Thorium-232
SLD83224	0.95	2.83	0.77
SLD83224-1	1.15	2.88	1.14
SLD83224-2	0.93	2.54	0.64
SLD83230	0.94	1.64	0.85
SLD83230-1	0.54	1.36	0.43
SLD83230-2	0.67	1.24	0.53
SLD83543	0.72	1.59	0.41
SLD83543-1	0.53	1.36	0.46
SLD83543-2	0.50	1.15	0.40
SLD84106	1.68	1.45	1.06
SLD84106-1	1.48	1.71	0.82
SLD84106-2	0.90	0.91	0.79
SLD85135	1.32	1.89	0.70
SLD85135-1	1.10	1.31	0.77
SLD85135-2	*	*	*

* Analysis not conducted.

Table C-2-6. Gamma Spec Results for Parent Samples and the Associated Field Duplicates and Field Splits

Sample Name	Actinium-227	Americium-241	Cesium-137	Potassium-40	Protactinium-231	Radium-226	Radium-228	Uranium-235	Uranium-238
SLD83224	0.05	0.00	0.02	9.18	0.43	1.890	0.68	1.02	13.96
SLD83224-1	-0.07	0.09	0.04	8.07	-0.27	1.862	0.66	0.93	15.19
SLD83224-2	0.20	0.16	0.05	7.10	-0.30	a 1.935	0.74	1.04	17.00
SLD83230	0.01	0.04	0.03	8.53	0.22	1.093	0.63	0.72	9.11
SLD83230-1	0.14	0.02	0.01	9.28	0.12	1.085	0.58	0.46	7.68
SLD83230-2	0.16	-0.02	0.00	8.40	-0.88	a 0.99	0.66	0.07	3.50
SLD83543	-0.16	0.03	0.05	7.75	0.06	1.221	0.41	0.10	1.24
SLD83543-1	-0.08	0.02	0.03	6.55	0.29	1.130	0.35	0.07	1.34
SLD83543-2	-0.01	0.01	0.01	5.90	0.11	a 1.035	0.27	0.07	0.90
SLD84106	-0.09	0.00	-0.01	14.57	0.25	1.132	0.81	0.18	1.76
SLD84106-1	-0.12	0.03	0.00	11.67	0.26	0.955	0.63	0.11	1.61
SLD84106-2	0.08	0.01	0.04	16.40	-1.10	a 1.2	0.87	0.30	1.10
SLD85135	-0.03	-0.01	-0.03	16.03	-0.07	1.005	0.81	0.32	4.44
SLD85135-1	-0.13	-0.06	-0.03	14.98	0.38	0.961	0.76	0.00	2.89
SLD85135-2	*	*	*	*	*	*	*	*	*

* – Analysis not conducted.

a – Value corrected by a factor of 1.5 for comparability.

ATTACHMENT C-3
DT-29 FINAL STATUS SURVEY SOIL SAMPLE DATA

Survey Unit	Sample Name	Actinium-227			Protactinium-231			Radium-226			Radium-228			Thorium-228			Thorium-230			Thorium-232			Uranium-235			Uranium-238		
		Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ
SU-1	HTZ76852	0.06	0.16	UJ	0.36	0.72	UJ	1.51	0.06	=	0.83	0.07	J	1.66	0.15	J	3.66	0.15	=	1.16	0.15	=	1.71	0.36	=	28.01	0.35	=
SU-1	HTZ76853	0.05	0.15	UJ	0.14	0.58	UJ	1.39	0.05	=	0.91	0.05	J	1.91	0.14	J	2.80	0.27	=	1.06	0.14	=	0.76	0.29	=	13.67	0.30	=
SU-1	HTZ84042	0.42	0.21	=	0.88	1.46	U	7.76	0.17	=	0.82	0.20	=	1.17	0.13	=	3.07	0.13	=	0.78	0.13	J	0.52	0.37	=	8.15	2.85	=
SU-1	HTZ84043	-0.03	0.41	UJ	0.31	1.01	UJ	1.09	0.12	=	0.89	0.12	=	1.61	0.15	=	1.56	0.15	=	0.65	0.15	J	0.06	0.20	UJ	0.60	1.03	UJ
SU-1	HTZ84044	-0.20	0.52	UJ	-0.33	1.38	UJ	2.15	0.15	=	1.13	0.17	=	1.28	0.14	=	2.60	0.26	=	1.13	0.14	=	1.23	0.41	=	24.10	1.59	=
SU-1	HTZ84045	-0.27	0.54	UJ	0.83	1.43	UJ	2.93	0.17	=	1.38	0.15	=	1.38	0.14	=	4.11	0.14	=	1.03	0.14	=	1.32	0.42	=	29.81	1.74	=
SU-1	HTZ84046	2.79	0.19	=	2.63	0.73	=	2.61	0.14	=	1.20	0.12	=	1.47	0.27	=	4.01	0.23	=	1.52	0.23	=	2.62	0.33	=	41.69	1.79	=
SU-1	HTZ84047	5.27	0.20	=	5.52	0.82	=	2.59	0.08	=	1.29	0.13	=	1.49	0.27	=	7.13	0.11	=	1.08	0.11	=	3.66	0.43	=	59.16	2.08	=
SU-1	HTZ84048	1.45	0.16	=	1.10	0.80	=	1.85	0.13	=	1.07	0.12	=	1.21	0.24	=	5.39	0.32	=	1.26	0.24	=	1.43	0.34	=	24.96	1.45	=
SU-1	HTZ84049	3.13	0.33	U	-0.28	0.92	UJ	1.43	0.10	=	0.71	0.10	=	0.89	0.22	=	1.94	0.12	=	0.90	0.12	=	0.98	0.21	=	17.67	1.12	=
SU-1	HTZ84050	0.29	0.13	=	0.38	1.00	UJ	1.44	0.11	=	0.48	0.09	=	1.01	0.37	J	3.98	0.17	=	0.92	0.17	J	0.84	0.29	=	15.95	1.13	=
SU-1	HTZ84051	-0.11	0.38	UJ	-0.46	1.07	UJ	1.70	0.13	=	0.91	0.14	=	1.37	0.24	=	13.02	0.32	=	0.86	0.13	=	2.89	0.38	=	61.70	1.69	=
SU-1	SLD83214	0.43	0.09	=	0.61	0.52	U	0.92	0.04	=	0.27	0.04	=	0.26	0.29	U	3.32	0.13	=	0.29	0.13	J	0.74	0.24	=	9.66	0.26	=
SU-1	SLD83218	0.08	0.14	UJ	0.24	0.58	UJ	1.48	0.05	=	0.92	0.05	=	1.93	0.13	=	2.75	0.24	=	1.59	0.13	=	1.05	0.40	U	19.49	0.40	=
SU-1	SLD83219	0.29	0.18	U	0.38	0.75	UJ	4.21	0.06	=	1.09	0.06	=	1.60	0.28	=	6.02	0.13	=	1.06	0.13	=	0.47	0.39	=	7.07	0.36	=
SU-1	SLD83222	0.00	0.15	UJ	0.13	0.70	UJ	1.36	0.06	=	0.85	0.06	J	1.26	0.28	J	2.65	0.24	=	1.03	0.24	=	0.90	0.33	=	13.92	0.38	=
SU-1	SLD83223	-0.02	0.15	UJ	0.44	0.64	U	2.28	0.05	=	0.88	0.05	J	1.12	0.25	J	1.86	0.25	J	0.92	0.25	=	0.24	0.32	U	4.02	0.27	=
SU-1	SLD83224	0.05	0.16	UJ	0.43	0.72	UJ	1.89	0.06	=	0.68	0.06	J	0.95	0.15	J	2.83	0.28	=	0.77	0.28	J	1.02	0.35	=	13.96	0.36	=
SU-1	SLD83224-1	-0.07	0.25	UJ	-0.27	1.03	UJ	1.86	0.10	=	0.66	0.10	J	1.15	0.13	J	2.88	0.13	=	1.14	0.24	=	0.93	0.55	=	15.19	0.70	=
SU-1	SLD83224-2	0.20	0.51	UJ	-0.30	2.10	UJ	1.29	0.25	=	0.74	0.31	=	0.93	0.17	=	2.54	0.09	=	0.74	0.31	=	1.04	1.30	U	17.00	2.00	=
SU-1	SLD83225	0.17	0.21	UJ	0.07	0.85	UJ	3.22	0.07	=	1.49	0.08	J	1.73	0.24	J	2.97	0.33	=	1.69	0.13	=	1.62	0.42	=	27.48	0.43	=
SU-1	SLD83228	0.08	0.12	UJ	0.27	0.53	UJ	1.41	0.04	=	0.64	0.04	=	1.21	0.28	=	2.33	0.28	J	0.56	0.15	J	0.90	0.27	=	14.68	0.26	=
SU-1	SLD83229	-0.20	0.17	UJ	0.06	0.75	UJ	1.20	0.07	=	0.87	0.07	=	1.57	0.32	=	3.84	0.32	=	1.07	0.17	J	0.65	0.39	=	10.21	0.47	=
SU-1	SLD83230	0.01	0.12	UJ	0.22	0.50	UJ	1.09	0.05	=	0.63	0.05	J	0.94	0.25	J	1.64	0.25	J	0.85	0.14	J	0.72	0.26	=	9.11	0.28	=
SU-1	SLD83230-1	0.14	0.10	J	0.12	0.43	UJ	1.09	0.04	=	0.58	0.04	J	0.54	0.13	J	1.36	0.25	J	0.43	0.25	J	0.46	0.23	=	7.68	0.25	=
SU-1	SLD83230-2	0.16	0.36	UJ	-0.88	1.30	UJ	0.66	0.39	=	0.66	0.20	=	0.67	0.17	=	1.24	0.10	=	0.66	0.20	=	0.07	0.78	UJ	3.50	1.30	=
SU-1	SLD83231	0.06	0.31	UJ	0.58	1.29	UJ	5.55	0.11	=	1.05	0.11	J	1.40	0.16	J	5.25	0.16	=	1.40	0.16	=	0.01	0.65	UJ	4.39	0.62	=
SU-1	SLD83236	0.15	0.20	UJ	0.91	0.88	U	4.29	0.07	=	1.20	0.07	=	1.83	0.28	=	3.68	0.28	=	1.23	0.15	=	1.35	0.44	=	25.17	0.48	=
SU-1	SLD83237	0.11	0.22	UJ	0.69	0.96	U	4.66	0.08	=	1.16	0.09	=	1.80	0.14	=	3.86	0.26	=	0.81	0.26	J	1.65	0.48	=	24.95	0.53	=
SU-1	SLD83531	0.12	0.11	U	0.18	0.46	UJ	1.24	0.04	=	0.22	0.04	=	0.12	0.34	UJ	1.09	0.12	J	0.25	0.22	J	0.28	0.25	U	4.42	0.22	=
SU-1	SLD83532	1.01	0.11	=	0.95	0.85	=	1.06	0.04	=	0.25	0.05	=	0.26	0.29	U	2.07	0.13	J	0.29	0.13	J	1.18	0.27	=	17.55	0.40	=
SU-1	SLD83533	0.01	0.11	UJ	0.09	0.51	UJ	1.49	0.04	=	0.48	0.05	=	0.69	0.29	J	2.79	0.29	J	0.82	0.16	J	0.19	0.26	U	3.59	0.20	=
SU-1	SLD83534	0.30	0.18	U	0.30	0.79	UJ	3.47	0.08	=	1.03	0.07	=	1.33	0.28	J	2.57	0.28	J	1.34	0.15	=	0.12	0.40	UJ	3.12	0.31	=
SU-1	SLD83539	0.00	0.11	UJ	0.08	0.56	UJ	1.38	0.05	=	0.47	0.05	=	1.03	0.32	=	1.88	0.32	J	0.73	0.27	J	0.16	0.29	UJ	4.39	0.24	=
SU-1	SLD83540	0.11	0.26	UJ	-0.34	1.05	UJ	6.23	0.10	=	1.08	0.10	=	2.16	0.30	=	5.03	0.30	J	1.47	0.16	=	0.19	0.55	UJ	6.22	0.49	=
SU-1	SLD83541	-0.02	0.09	UJ	0.04	0.39	UJ	1.16	0.03	=	0.32	0.03	=	0.33	0.46	U	0.99	0.16	J	0.41	0.16	J	0.14	0.21	U	2.45	0.16	=
SU-1	SLD83542	0.27	0.16	U	0.25	0.66	UJ	2.91	0.06	=	0.89	0.06	=	1.75	0.18	=	4.11	0.18	=	1.01	0.18	J	0.02	0.33	UJ	2.37	0.30	=
SU-1	SLD83543	-0.16	0.11	UJ	0.06	0.48	UJ	1.22	0.05	=	0.41	0.04	=	0.72	0.32	J	1.59	0.24	=	0.41	0.24	J	0.10	0.26	UJ	1.24	0.29	=
SU-1	SLD83543-1	-0.08	0.11	UJ	0.29	0.47	UJ	1.13	0.04	=	0.35	0.04	=	0.53	0.36	J	1.36	0.13	=	0.46	0.29	J	0.07	0.23	UJ	1.34	0.19	=
SU-1	SLD83543-2	-0.01	0.31	UJ	0.11	1.50	UJ	0.69	0.19	=	0.27	0.40	U	0.50	0.14	=	1.15	0.09	=	0.40	0.07	=	0.07	0.70	UJ	0.90	1.40	UJ
SU-1	SLD83544	0.02	0.18	UJ	0.16	0.75	UJ	3.55	0.05	=	1.02	0.06	=	1.70	0.31	=	2.59	0.31	=	1.14	0.26	=	0.32	0.37	U	2.17	0.35	=
SU-1	SLD83545	0.28	0.10	=	0.36	0.56	U	1.37	0.04	=	0.28	0.04	J	0.55	0.26	J	2.06	0.14	=	0.05	0.14	UJ	0.19	0.29	U	4.20	0.27	=
SU-1	SLD83546	0.31	0.18	=	0.26	0.91	UJ	5.91	0.08	=	0.91	0.07	=	1.37	0.42	=	4.23	0.15	=	1.03	0.15	J	0.42	0.45	U	9.65	0.47	=
SU-1	SLD83547	-0.04	0.09	UJ	-0.13	0.38	UJ	0.98	0.03	=	0.23	0.04	J	0.49	0.31	J	1.24	0.14	=	0.49	0.31	J	0.09	0.20	UJ	1.41	0.17	J
SU-1	SLD83548	0.06	0.14	UJ	-0.39	0.67	UJ	1.27	0.07	=	0.42	0.06	=	0.34	0.32	J	1.25	0.28	=	0.33	0.13	J	0.06	0.31	UJ	1.44	0.30	=
SU-1	SLD83549	-0.05	0.11	UJ	-0.08	0.49	UJ	1.23	0.05	=	0.34	0.04	=	0.46	0.24	J	0.89	0.24	=	0.43	0.13	J	-0.04	0.24	UJ	2.00	0.19	=
SU-1	SLD83550	-0.01	0.10	UJ	-0.01	0.41	UJ	1.03	0.04	=	0.31	0.04	=	0.58	0.30	J	1.39	0.30	=	0.35	0.14	J	0.10	0.21	UJ	0.74	0.18	=
SU-1	SLD83563	-0.13	0.18	UJ	0.06	0.80	UJ	2.92	0.07	=	0.83	0.06	=	1.10	0.16	=	2.43	0.16	=	1.21	0.16	=	0.37	0.40	U	7.26	0.41	=

DT-29 Final Status Survey Soil Sample Data

Survey Unit	Sample Name	Actinium-227			Protactinium-231			Radium-226			Radium-228			Thorium-228			Thorium-230			Thorium-232			Uranium-235			Uranium-238		
		Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ	Result	MDA	VQ
SU-1	SLD83564	0.06	0.44	UJ	1.24	2.03	U	3.24	0.21	=	1.15	0.20	=	1.58	0.37	=	3.47	0.17	=	1.71	0.31	=	0.71	1.09	U	9.70	0.84	=
SU-1	SLD83665	0.00	0.13	UJ	0.13	0.51	UJ	1.53	0.04	=	0.81	0.04	=	0.73	0.38	J	1.56	0.14	=	0.92	0.26	J	0.20	0.28	U	3.61	0.24	=
SU-1	SLD83666	-0.08	0.12	UJ	0.09	0.53	UJ	1.04	0.05	=	0.80	0.04	=	1.40	0.36	J	1.63	0.23	=	0.40	0.23	J	0.09	0.26	UJ	1.35	0.23	=
SU-1	SLD84099	0.18	0.09	=	0.23	0.50	UJ	1.23	0.04	=	0.57	0.04	=	1.18	0.29	=	1.39	0.24	J	0.39	0.13	J	0.27	0.23	J	4.38	0.22	=
SU-1	SLD84100	0.03	0.18	UJ	-0.11	0.68	UJ	1.72	0.07	=	0.71	0.06	=	0.76	0.28	J	1.91	0.33	J	0.83	0.15	J	0.20	0.34	UJ	3.25	0.29	=
SU-1	SLD84101	0.03	0.10	UJ	0.02	0.39	UJ	0.82	0.03	=	0.37	0.03	=	0.99	0.31	=	1.37	0.26	J	0.71	0.14	J	0.20	0.20	U	1.69	0.17	=
SU-1	SLD84102	-0.04	0.14	UJ	-0.02	0.55	UJ	1.35	0.05	=	0.51	0.05	=	0.70	0.31	J	1.02	0.26	J	0.36	0.14	J	0.22	0.24	U	2.63	0.23	=
SU-1	SLD84103	0.14	0.11	U	0.46	0.44	U	1.28	0.04	=	0.40	0.04	=	0.92	0.34	J	1.39	0.30	J	0.66	0.14	J	0.33	0.20	=	3.17	0.20	=
SU-1	SLD84104	0.10	0.10	U	0.18	0.43	UJ	1.04	0.04	=	0.41	0.04	=	0.52	0.12	J	0.56	0.12	J	0.56	0.12	J	0.03	0.20	UJ	0.85	0.17	=
SU-1	SLD84105	0.01	0.11	UJ	0.09	0.42	UJ	1.08	0.04	=	0.37	0.04	=	0.49	0.23	J	0.91	0.12	=	0.50	0.12	J	0.26	0.20	U	0.96	0.16	=
SU-1	SLD84106	-0.09	0.13	UJ	0.25	0.61	UJ	1.13	0.05	=	0.81	0.05	=	1.68	0.30	=	1.45	0.25	=	1.06	0.14	=	0.18	0.28	UJ	1.76	0.25	=
SU-1	SLD84106-1	-0.12	0.12	UJ	0.26	0.49	UJ	0.95	0.04	=	0.63	0.04	=	1.48	0.24	=	1.71	0.29	=	0.82	0.13	J	0.11	0.23	UJ	1.61	0.20	=
SU-1	SLD84106-2	0.08	0.39	UJ	-1.10	1.90	UJ	0.80	0.50	=	0.87	0.34	=	0.90	0.23	=	0.91	0.12	J	0.87	0.34	=	0.30	0.99	UJ	1.10	2.00	U
SU-1	SLD85135	-0.03	0.37	UJ	-0.07	0.99	UJ	1.00	0.11	=	0.81	0.11	=	1.32	0.21	=	1.89	0.25	=	0.70	0.11	J	0.32	0.22	=	4.44	0.92	=
SU-1	SLD85135-1	-0.13	0.34	UJ	0.38	0.88	UJ	0.96	0.10	=	0.76	0.12	=	1.10	0.14	=	1.31	0.14	=	0.77	0.26	J	0.00	0.18	UJ	2.89	0.94	=
SU-1	SLD85138	7.16	0.62	U	-0.30	1.58	UJ	3.95	0.19	=	1.73	0.20	=	2.28	0.13	=	5.00	0.25	=	1.32	0.25	=	2.15	0.49	=	41.94	1.75	=

Notes:

All Results are in picocuries per gram (pCi/g)

MDA = Method Detection Activity

VQ = Data Validation Qualifier

ATTACHMENT C-4
DT-29 FINAL STATUS SURVEY SOIL SAMPLE DATA SUMMARY

Reference Area Data Summary

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

DT-29 Survey Unit 1 Class 1 Surface Data Summary

Statistic	Sample Type	Ra-226	Th-230	U-238	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231	SOR_G	SOR_N
Mean	Systematic	1.39	1.98	7.84	0.48	0.66	0.56	0.90	0.39	0.15	0.60	0.18
Median	Systematic	1.24	1.64	4.38	0.27	0.66	0.47	0.92	0.01	0.13	0.48	0.06
Standard Deviation	Systematic	0.63	0.99	9.42	0.51	0.36	0.34	0.53	1.55	0.21	0.29	0.26
Number of samples	Systematic	21	21	21	21	21	21	21	21	21	21	21
Maximum	All	7.76	13.02	61.70	3.66	1.59	1.73	2.28	7.16	5.52	2.16	1.94
Range	All	6.94	12.13	61.10	3.66	1.54	1.52	2.16	7.16	5.52	1.99	1.94

SampleName	HTZ Area (m^2)	Sample Type	Ra-226	Th-230	U-238	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231	SOR_G	SOR_N
HTZ76852	0.5	Biased	1.51	3.66	28.01	1.71	1.16	0.83	1.66	0.06	0.36	1.53	0.89
HTZ84042*	1.0	Biased	7.76	3.07	8.15	0.52	0.78	0.82	1.17	0.42	0.88	0.74	0.47
HTZ84043*	1.0	Biased	1.09	1.56	0.60	0.06	0.65	0.89	1.61	-0.03	0.31	0.18	0.00
HTZ84044*	1.0	Biased	2.15	2.60	24.10	1.23	1.13	1.13	1.28	-0.20	-0.33	0.73	0.51
HTZ84045*	1.0	Biased	2.93	4.11	29.81	1.32	1.03	1.38	1.38	-0.27	0.83	0.96	0.74
HTZ84046*	0.5	Biased	2.61	4.01	41.69	2.62	1.52	1.20	1.47	2.79	2.63	1.20	0.97
HTZ84047*	0.5	Biased	2.59	7.13	59.16	3.66	1.08	1.29	1.49	5.27	5.52	1.74	1.52
HTZ84048*	0.5	Biased	1.85	5.39	24.96	1.43	1.26	1.07	1.21	1.45	1.10	0.94	0.71
HTZ84049*	1.0	Biased	1.43	1.94	17.67	0.98	0.90	0.71	0.89	3.13	-0.28	0.54	0.32
HTZ84050*	1.0	Biased	1.44	3.98	15.95	0.84	0.92	0.48	1.01	0.29	0.38	0.65	0.43
HTZ84051*	1.0	Biased	1.70	13.02	61.70	2.89	0.86	0.91	1.37	-0.11	-0.46	2.16	1.94
SLD83214*		Systematic	0.92	3.32	9.66	0.74	0.29	0.27	0.26	0.43	0.61	0.43	0.26
SLD83218		Systematic	1.48	2.75	19.49	1.05	1.59	0.92	1.93	0.08	0.24	1.26	0.62
SLD83222*		Systematic	1.36	2.65	13.92	0.90	1.03	0.85	1.26	0.00	0.13	0.52	0.30
SLD83224		Systematic	1.89	2.83	13.96	1.02	0.77	0.68	0.95	0.05	0.43	1.00	0.43
SLD83228		Systematic	1.41	2.33	14.68	0.90	0.56	0.64	1.21	0.08	0.27	0.89	0.34
SLD83230		Systematic	1.09	1.64	9.11	0.72	0.85	0.63	0.94	0.01	0.22	0.68	0.15
SLD83531		Systematic	1.24	1.09	4.42	0.28	0.25	0.22	0.12	0.12	0.18	0.39	0.06
SLD83533		Systematic	1.49	2.79	3.59	0.19	0.82	0.48	0.69	0.01	0.09	0.79	0.21
SLD83539		Systematic	1.38	1.88	4.39	0.16	0.73	0.47	1.03	0.00	0.08	0.61	0.06
SLD83541		Systematic	1.16	0.99	2.45	0.14	0.41	0.32	0.33	-0.02	0.04	0.36	0.02
SLD83543		Systematic	1.22	1.59	1.24	0.10	0.41	0.41	0.72	-0.16	0.06	0.43	0.00
SLD83545		Systematic	1.37	2.06	4.20	0.19	0.05	0.28	0.55	0.28	0.36	0.55	0.08
SLD83547		Systematic	0.98	1.24	1.41	0.09	0.49	0.23	0.49	-0.04	-0.13	0.37	0.00
SLD83549		Systematic	1.23	0.89	2.00	-0.04	0.43	0.34	0.46	-0.05	-0.08	0.37	0.01
SLD83665		Systematic	1.53	1.56	3.61	0.20	0.92	0.81	0.73	0.00	0.13	0.57	0.04
SLD84099		Systematic	1.23	1.39	4.38	0.27	0.39	0.57	1.18	0.18	0.23	0.48	0.06
SLD84101		Systematic	0.82	1.37	1.69	0.20	0.71	0.37	0.99	0.03	0.02	0.45	0.00
SLD84103		Systematic	1.28	1.39	3.17	0.33	0.66	0.40	0.92	0.14	0.46	0.47	0.03
SLD84105		Systematic	1.08	0.91	0.96	0.26	0.50	0.37	0.49	0.01	0.09	0.34	0.00
SLD85135*		Systematic	1.00	1.89	4.44	0.32	0.70	0.81	1.32	-0.03	-0.07	0.27	0.06
SLD85138*		Systematic	3.95	5.00	41.94	2.15	1.32	1.73	2.28	7.16	-0.30	1.29	1.07

* Sample collected at a depth of ≥ 0.5 feet below the original surface.

Reference Area Data Summary

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

DT-29 Survey Unit 1 Subsurface Data Summary

Statistic		Ra-226	Th-230	U-238	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231	SOR_G	SOR_N
Mean		2.81	2.87	8.13	0.48	0.97	0.86	1.31	0.11	0.27	0.45	0.22
Median		2.91	2.59	4.39	0.24	1.06	0.89	1.40	0.06	0.18	0.42	0.16
Standard Deviation		1.70	1.46	8.26	0.51	0.43	0.31	0.54	0.24	0.40	0.24	0.21
Systematic Std. Dev.		1.80	1.56	8.78	0.54	0.42	0.33	0.56	0.25	0.36	0.26	0.22
Number of samples		23	23	23	23	23	23	23	23	23	23	23
Maximum		6.23	6.02	27.48	1.65	1.71	1.49	2.16	1.01	1.24	0.89	0.63
Range		5.20	5.46	26.74	1.64	1.42	1.23	1.89	1.01	1.24	0.76	0.63

SampleName	StationName	Ra-226	Th-230	U-238	U-235	Th-232	Ra-228	Th-228	Ac-227	Pa-231	SOR_G	SOR_N	Depth Below Surface(1)
HTZ76853	HTZ76852	1.39	2.80	13.67	0.76	1.06	0.91	1.91	0.05	0.14	0.53	0.30	0.5-1.0
SLD83219	SLD83218	4.21	6.02	7.07	0.47	1.06	1.09	1.60	0.29	0.38	0.62	0.39	2.0-2.5
SLD83223	SLD83222	2.28	1.86	4.02	0.24	0.92	0.88	1.12	-0.02	0.44	0.29	0.05	1.5-2.0
SLD83225	SLD83224	3.22	2.97	27.48	1.62	1.69	1.49	1.73	0.17	0.07	0.88	0.63	0.5-1.0
SLD83229	SLD83228	1.20	3.84	10.21	0.65	1.07	0.87	1.57	-0.20	0.06	0.53	0.30	0.5-1.0
SLD83231	SLD83230	5.55	5.25	4.39	0.01	1.40	1.05	1.40	0.06	0.58	0.55	0.30	2.0 - 2.5
SLD83532	SLD83531	1.06	2.07	17.55	1.18	0.29	0.25	0.26	1.01	0.95	0.51	0.33	0.5 - 1.0
SLD83534	SLD83533	3.47	2.57	3.12	0.12	1.34	1.03	1.33	0.30	0.30	0.38	0.10	2.0 - 2.5
SLD83236	SLD81677	4.29	3.68	25.17	1.35	1.23	1.20	1.83	0.15	0.91	0.87	0.61	0.5 - 1.0
SLD83237	SLD81677	4.66	3.86	24.95	1.65	0.81	1.16	1.80	0.11	0.69	0.89	0.61	1.0 - 1.5
SLD83540	SLD83539	6.23	5.03	6.22	0.19	1.47	1.08	2.16	0.11	-0.34	0.64	0.35	2.0 - 2.5
SLD83542	SLD83541	2.91	4.11	2.37	0.02	1.01	0.89	1.75	0.27	0.25	0.39	0.16	1.0 - 1.5
SLD83544	SLD83543	3.55	2.59	2.17	0.32	1.14	1.02	1.70	0.02	0.16	0.36	0.07	1.5 - 2.0
SLD83546	SLD83545	5.91	4.23	9.65	0.42	1.03	0.91	1.37	0.31	0.26	0.66	0.37	1.5 - 2.0
SLD83548	SLD83547	1.27	1.25	1.44	0.06	0.33	0.42	0.34	0.06	-0.39	0.14	0.00	1.5 - 2.0
SLD83550	SLD83549	1.03	1.39	0.74	0.10	0.35	0.31	0.58	-0.01	-0.01	0.13	0.00	2.0 - 2.5
SLD83666	SLD83665	1.04	1.63	1.35	0.09	0.40	0.80	1.40	-0.08	0.09	0.19	0.00	0.5 - 1.0
SLD84100	SLD84099	1.72	1.91	3.25	0.20	0.83	0.71	0.76	0.03	-0.11	0.25	0.04	1.5 - 2.0
SLD84102	SLD84101	1.35	1.02	2.63	0.22	0.36	0.51	0.70	-0.04	-0.02	0.18	0.02	0.5 - 1.0
SLD84104	SLD84103	1.04	0.56	0.85	0.03	0.56	0.41	0.52	0.10	0.18	0.12	0.00	1.5 - 2.0
SLD84106	SLD84105	1.13	1.45	1.76	0.18	1.06	0.81	1.68	-0.09	0.25	0.20	0.01	1.5 - 2.0
SLD83563(2)	SLD83226	2.92	2.43	7.26	0.37	1.21	0.83	1.10	-0.13	0.06	0.42	0.16	4.0 - 4.5
SLD83564(2)	SLD83226	3.24	3.47	9.70	0.71	1.71	1.15	1.58	0.06	1.24	0.54	0.31	5.5 - 6.0

(1) - Depth below original grade

(2) - Sample collected below concrete (SU-2)

ATTACHMENT C-5
DT-29 EVALUATION OF 100-m^2 REMEDIATION GOAL

Vicinity Property	Survey Unit	Sample Number	SOR_N	Effective Surface Area (m^2)	Area Weighted Average SOR
Evaluation of 100 m^2 Aerial Average Remediation Goal					
DT-29	SU-1	**HTZ84047**	**1.52**	12.0	0.38
		HTZ84048	0.71	11.0	
		HTZ84046	0.97	11.0	
		SLD84100	0.04	33.0	
		SLD84106	0.01	33.0	
DT-29	SU-1	**HTZ84051**	**1.94**	1.0	0.55
		SLD85138	**1.07**	33.0	
		SLD83542	0.16	32.0	
		HTZ84049	0.32	16.0	
		HTZ84050	0.43	16.0	
		HTZ84044	0.51	2.0	

The area weighted average with $SOR_N > 1 = 1.21$

Bold font indicates $SOR_N > 1$

ATTACHMENT C-6
DT-29 WRS TEST

Sample	Data	Area	Adjusted Data	ADJ Ranks	Reference Area Ranks (Wr)
SLD00001	0.25	R	1.245	29	29
SLD00002	0.25	R	1.246	30	30
SLD00022	0.30	R	1.298	40	40
SLD00023	0.29	R	1.292	38	38
SLD00041	0.27	R	1.272	37	37
SLD00042	0.31	R	1.309	43	43
SLD00043	0.31	R	1.314	44	44
SLD00044	0.34	R	1.337	47	47
SLD00061	0.33	R	1.332	46	46
SLD00062	0.30	R	1.297	39	39
SLD00063	0.22	R	1.224	24	24
SLD00081	0.27	R	1.270	36	36
SLD00082	0.30	R	1.304	42	42
SLD00083	0.23	R	1.226	25	25
SLD00101	0.41	R	1.405	50	50
SLD00102	0.38	R	1.380	49	49
SLD00103	0.30	R	1.300	41	41
SLD00121	0.35	R	1.347	48	48
SLD00122	0.26	R	1.264	34	34
SLD00123	0.33	R	1.325	45	45
SLD00141	0.54	R	1.544	52	52
SLD00142	0.49	R	1.491	51	51
SLD00143	0.24	R	1.242	27	27
SLD00144	0.25	R	1.252	31	31
SLD00161	0.19	R	1.194	20	20
SLD00162	0.23	R	1.227	26	26
SLD00181	0.22	R	1.220	23	23
SLD00201	0.26	R	1.255	32	32
SLD00202	0.26	R	1.265	35	35
SLD00241	0.20	R	1.201	21	21
SLD00242	0.24	R	1.244	28	28
SLD00243	0.21	R	1.209	22	22
SLD83214	0.91	S	0.433	17	0
SLD83218	1.26	S	1.257	33	0
SLD83222	1.01	S	0.524	19	0
SLD83224	1.00	S	0.998	18	0
SLD83228	0.89	S	0.886	16	0
SLD83230	0.68	S	0.681	14	0
SLD83531	0.39	S	0.386	5	0
SLD83533	0.79	S	0.793	15	0
SLD83539	0.61	S	0.610	12	0
SLD83541	0.36	S	0.362	2	0
SLD83543	0.43	S	0.425	6	0
SLD83545	0.55	S	0.551	10	0
SLD83547	0.37	S	0.373	4	0
SLD83549	0.37	S	0.370	3	0
SLD83665	0.57	S	0.568	11	0
SLD84099	0.48	S	0.480	9	0
SLD84101	0.45	S	0.449	7	0
SLD84103	0.47	S	0.473	8	0
SLD84105	0.33	S	0.335	1	0
SLD85135	0.63	S	0.268	13	0
SLD85138	2.18	S	1.287	53	0
Number of Reference Area Measurements (m)				32	*Wr* 1155
Number of Systematic Measurements (n)				21	*Crit Val* 954
					Pass

Data points for the SU(s) are gross values (includes background).
Data points for the Reference Area (R) are background values.

ATTACHMENT C-7
DT-29 FINAL STATUS SURVEY GAMMA WALKOVER SURVEY MAPS

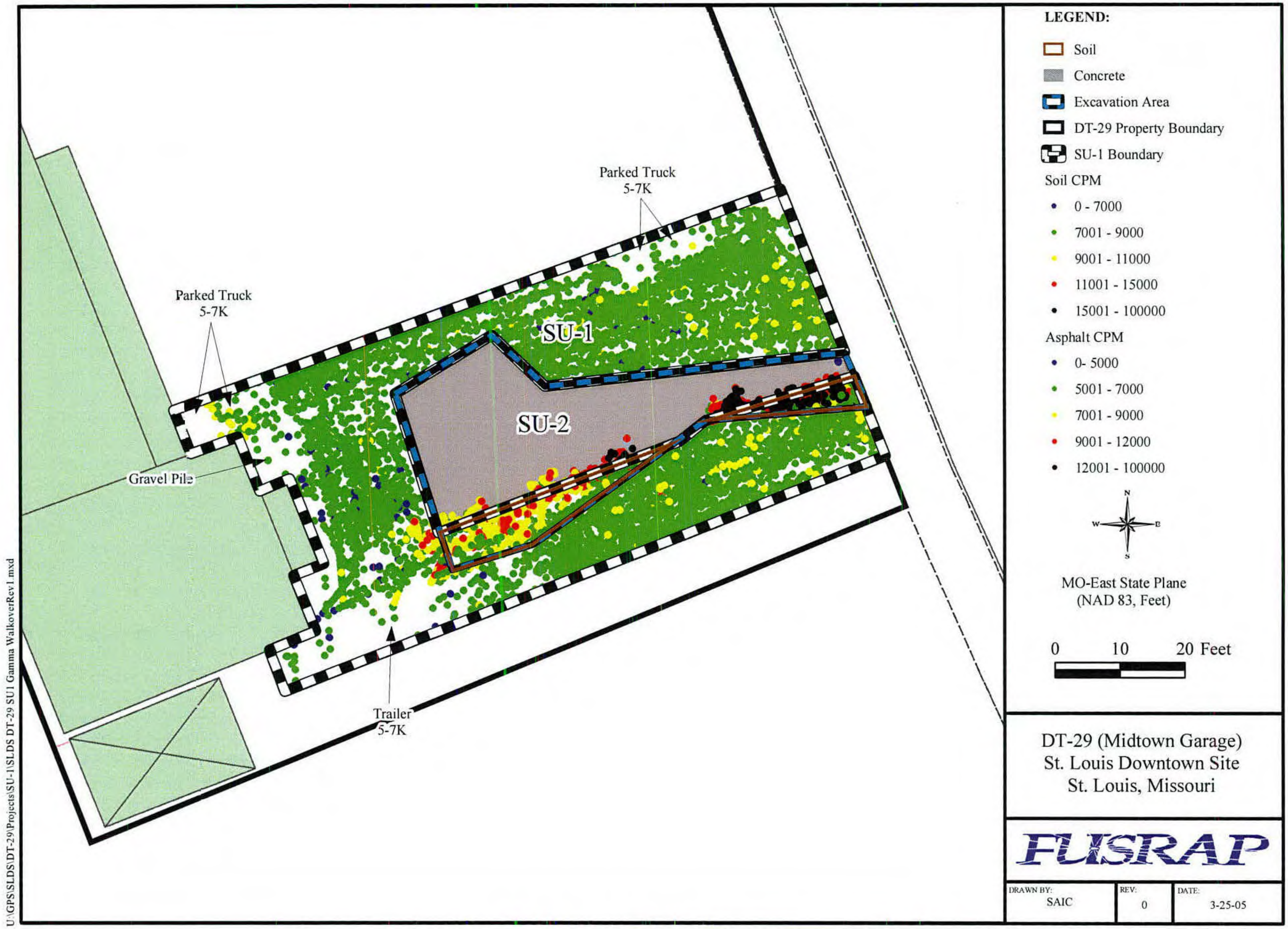

Figure C-7-1 DT-29 Gamma Walkover Survey

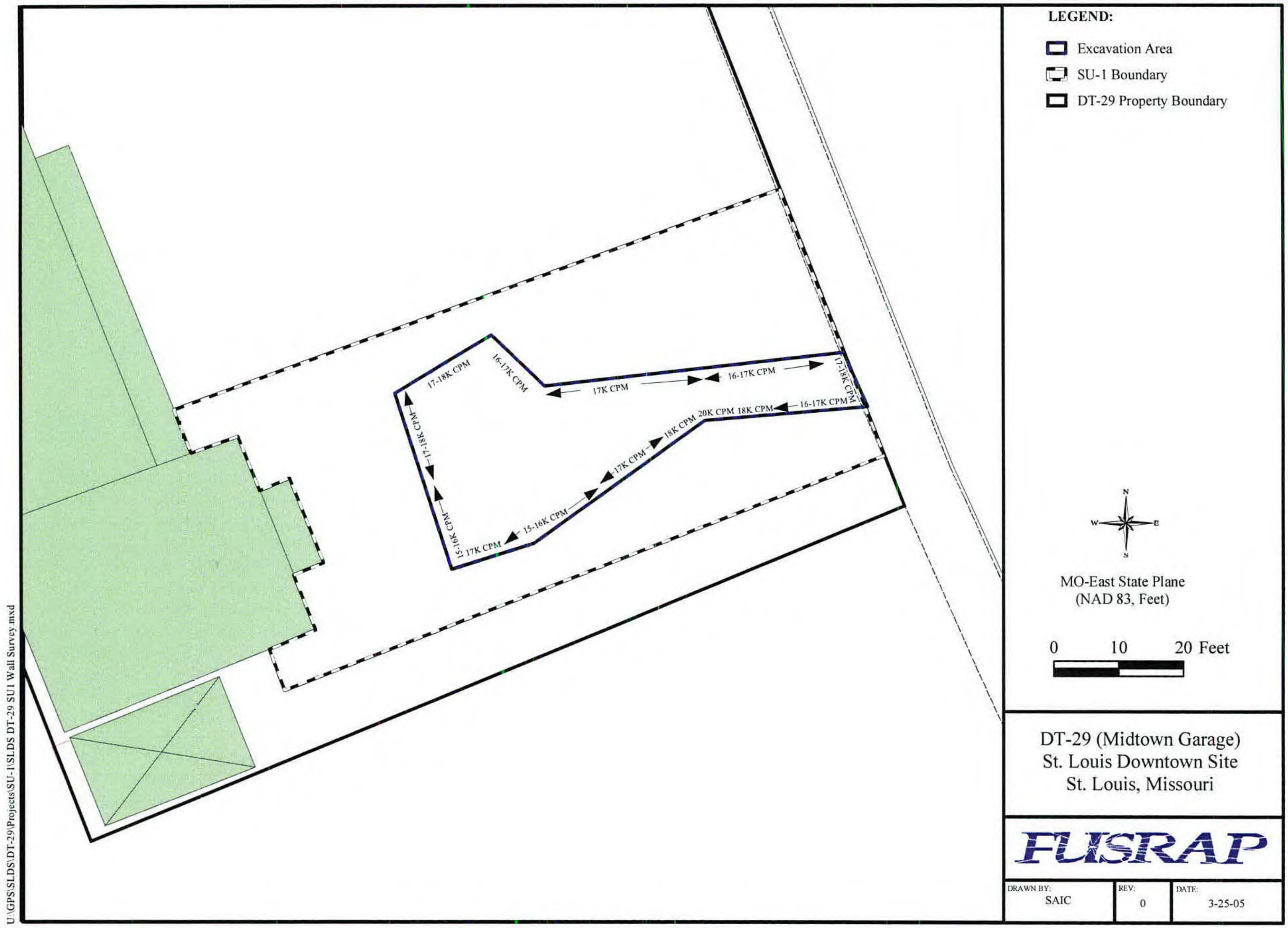

Figure C-7-2 DT-29 Wall Survey

ATTACHMENT C-8
DT-29 FINAL STATUS SURVEY FIXED POINT MEASUREMENTS DATA ON CONSOLIDATED MATERIAL SURFACES

Table C-8-1
DT-29 Final Point Measurements Results

		Alpha					Beta			
		e_i[a]	e_s[b]	e_{total}[c]			e_i[a]	e_s[b]	e_{total}[c]	
		0.12	0.25	0.03			0.254	0.25	0.064	
DT-29	Sample #	Gross (cpm)	BKGD (cpm)	Net (cpm)	dpm/100cm^2		Gross (cpm)	BKGD (cpm)	Net (cpm)	dpm/100cm^2
Systematic Concrete	2	3	0.33	2.67	71		222	166.7	55.3	697
Systematic Concrete	5	2	0.33	1.67	45		278	166.7	111.3	1,402
Systematic Concrete	8	1	0.33	0.67	18		176	166.7	9.3	117
Systematic Concrete	11	4	0.33	3.67	98		392	166.7	225.3	2,838
Systematic Concrete	14	8	0.33	7.67	205		308	166.7	141.3	1,780
Systematic Concrete	17	3	0.33	2.67	71		313	166.7	146.3	1,843
Systematic Concrete	20	6	0.33	5.67	151		273	166.7	106.3	1,339
Systematic Concrete	23	5	0.33	4.67	125		415	166.7	248.3	3,128
Systematic Concrete	41	3	0.33	2.67	71		313	166.7	146.3	1,843
Systematic Concrete	50	10	0.33	9.67	258		539	166.7	372.3	4,690
Systematic Concrete	53	11	0.33	10.67	285		431	166.7	264.3	3,330
Systematic Concrete	59	5	0.33	4.67	125		318	166.7	151.3	1,906
Systematic Concrete	61	6	0.33	5.67	151		570	166.7	403.3	5,081
Systematic Concrete	62	5	0.33	4.67	125		430	166.7	263.3	3,317
Systematic Concrete	65	4	0.33	3.67	98		250	166.7	83.3	1,049
Systematic Concrete	68	3	0.33	2.67	71		334	166.7	167.3	2,108
Systematic Concrete	71	6	0.33	5.67	151		542	166.7	375.3	4,728
Biased Concrete	1	2	0.33	1.67	45		265	166.7	98.3	1,238
Biased Concrete	3	3	0.33	2.67	71		258	166.7	91.3	1,150
Biased Concrete	4	4	0.33	3.67	98		278	166.7	111.3	1,402
Biased Concrete	6	2	0.33	1.67	45		254	166.7	87.3	1,100
Biased Concrete	7	8	0.33	7.67	205		667	166.7	500.3	6,303
Biased Concrete	9	7	0.33	6.67	178		620	166.7	453.3	5,711
Biased Concrete	10	2	0.33	1.67	45		318	166.7	151.3	1,906
Biased Concrete	12	4	0.33	3.67	98		287	166.7	120.3	1,516
Biased Concrete	13	6	0.33	5.67	151		360	166.7	193.3	2,435

		Alpha					Beta			
		e_i[a]	e_s[b]	e_{total}[c]			e_i[a]	e_s[b]	e_{total}[c]	
		0.15	0.25	0.038			0.26	0.25	0.065	
DT-29	Sample #	Gross (cpm)	BKGD (cpm)	Net (cpm)	dpm/100cm^2		Gross (cpm)	BKGD (cpm)	Net (cpm)	dpm/100cm^2
Systematic Concrete	26	6	0.66	5.34	114		380	209.7	170.3	2,096
Systematic Concrete	29	1	0.66	0.34	7		294	209.7	84.3	1,038
Systematic Concrete	32	4	0.66	3.34	71		710	209.7	500.3	6,158
Systematic Concrete	35	4	0.66	3.34	71		285	209.7	75.3	927
Systematic Concrete	38	6	0.66	5.34	114		490	209.7	280.3	3,450
Systematic Concrete	44	4	0.66	3.34	71		574	209.7	364.3	4,484
Systematic Concrete	47	5	0.66	4.34	93		586	209.7	376.3	4,631
Systematic Concrete	56	4	0.66	3.34	71		392	209.7	182.3	2,244
Biased Concrete	32-1	13	0.66	12.34	263		330	209.7	120.3	1,481
Biased Concrete	32-2	6	0.66	5.34	114		227	209.7	17.3	213
Biased Concrete	32-3	8	0.66	7.34	157		249	209.7	39.3	484
Biased Concrete	51	7	0.66	6.34	135		417	209.7	207.3	2,551

a e_i = Instrument Efficiency; b e_s = Surface Efficiency; c e_{total} = Total Efficiency

Table C-8-2
DT-29 Sign Tests

Survey Area	Measurement No.	ALPHA dpm/100cm^2	Alpha Difference[1]	BETA dpm/100cm^2	Beta Difference[2]
Systematic Concrete	2	71	529	697	5,303
Systematic Concrete	5	45	555	1,402	4,598
Systematic Concrete	8	18	582	117	5,883
Systematic Concrete	11	98	502	2,838	3,162
Systematic Concrete	14	205	395	1,780	4,220
Systematic Concrete	17	71	529	1,843	4,157
Systematic Concrete	20	151	449	1,339	4,661
Systematic Concrete	23	125	475	3,128	2,872
Systematic Concrete	26	114	486	2,096	3,904
Systematic Concrete	29	7	593	1,038	4,962
Systematic Concrete	32	71	529	6,158	-158
Systematic Concrete	35	71	529	927	5,073
Systematic Concrete	38	114	486	3,450	2,550
Systematic Concrete	41	71	529	1,843	4,157
Systematic Concrete	44	71	529	4,484	1,516
Systematic Concrete	47	93	507	4,631	1,369
Systematic Concrete	50	258	342	4,690	1,310
Systematic Concrete	53	285	315	3,330	2,670
Systematic Concrete	56	71	529	2,244	3,756
Systematic Concrete	59	125	475	1,906	4,094
Systematic Concrete	61	151	449	5,081	919
Systematic Concrete	62	125	475	3,317	2,683
Systematic Concrete	65	98	502	1,049	4,951
Systematic Concrete	68	71	529	2,108	3,892
Systematic Concrete	71	151	449	4,728	1,272
Test Statistics		**Alpha**		**Beta**	
s+			*25*		*24*
n			*25*		*25*
$k_{critical}$			*17*		*17*
Result			***Pass***		***Pass***

1 Alpha Difference is equal to difference between DCGL and the alpha results.
2 Beta Difference is equal to the difference between DCGL and the beta results.

Table C-8-3
DT-29 1m² Averaging Tests

Grid ID 7					
Sample ID	Area (cm^2)	Alpha dpm/100cm²	Beta dpm/100 cm²	Weighted Alpha	Weighted Beta
7	125	205	6303	2.56	78.79
*7-1	9875	71	1427	70.11	1409.16
TOTALS	**10000.0**			**73**	**1488**

*The alpha and beta values for sample 7-1 were determined from the scan results of the area, the highest values were used.

Grid ID 32					
Sample ID	Area (cm^2)	Alpha dpm/100cm²	Beta dpm/100 cm²	Weighted Alpha	Weighted Beta
32	125.0	71	6158	0.89	76.98
32-1	3291.6	263	1481	86.65	487.36
32-2	3291.7	114	213	37.50	70.09
32-3	3291.7	157	484	51.54	159.22
TOTALS	**10000.0**			**177**	**794**

Weighted Alpha or Beta = (Area/Total Area)*(Alpha or Beta Result)

Table C-8-4 Standard Deviation Calculations for Sign Test

Systematic Samples

Property	Survey Unit
DT-29	Concrete

Survey Points	Alpha dpm/100 cm2
1	71
2	45
3	18
4	98
5	205
6	71
7	151
8	125
9	114
10	7
11	71
12	71
13	114
14	71
15	71
16	93
17	258
18	285
19	71
20	125
21	151
22	125
23	98
24	71
25	151

Mean	**109**
Median	**98**
Standard Deviation	**65.50**
n (number of samples)	**25**

ATTACHMENT C-9
DT-29 ALARA ANALYSIS

ALARA ANALYSIS

10 CFR 20 Subpart E ARAR pertains to the extent to which lands must be remediated before decommissioning of a site can be considered complete and the license terminated. The standards are for unrestricted use, 25 mrem/yr TEDE and as ALARA and for unrestricted use, 25mrem/yr TEDE, 100 mrem/yr with loss of controls, and ALARA. Soils containing small areas of elevated activity (i.e. having a SOR value >1) that meet the RG may be left in place. Areas of elevated activity meet the RGs by demonstrating that the 40 CFR 192 ARAR is met and by showing that residual risks for DT-29 does not exceed the CERCLA target risk range.

An ALARA evaluation was performed consistent with NUREG-1727 (NRC 2000) as a measure of the cost effectiveness of leaving small elevated areas of soils in place verses the benefit of remediation. Soil samples with a SOR value in excess of 1.0 are listed in Attachment C-5.

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

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

Where:

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

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

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

Where:

P_D	=	population density for the critical group scenario in people/m^2, 0.0004.
A	=	area being evaluated in m^2, 46 m^2 is used as the sum of the areas exceeding a SOR value of 1 (see Table C-5-1)
0.025	=	annual dose to an average member of the critical group from residual radioactivity at the concentration-based RG in rem/yr.
F	=	fraction of the residual activity removed by the RA; in this case F = 1 to represent areas exceeding a SOR value of 1.
Conc	=	average concentration of residual radioactivity in the area being evaluated. The area weighted SOR_N for the elevated accessible soil areas of DT-29 is 1.21 (see Attachment 5, Table C-5-1)
$DCGL_W$	=	derived concentration guideline limit; in this case, SOR_N= 1.
r	=	monetary discount rate; 0.03/yr as recommended by NUREG-1727.
λ	=	radiological decay constant. U-238 was chosen as the representative decay constant because this would give the most conservative result (highest present worth factor) = 1.55 E-10/yr.

N = number of years over which the collective dose will be calculated; 1000 as recommended by NUREG-1727.

Although the SOR value of 1 that was used as the concentration-based RG for DT-29 is not based on the 25 mrem, using 0.025 rem/yr (i.e., 25 mrem/yr) in the equation is a conservative approach because the calculated doses from the elevated areas are all less than 25 mrem/yr. Using these equations, the benefit from the averted dose (B_{AD}) was calculated to be approximately $1.00.

The cost of remediating the remaining areas was based on actual costs incurred by remediation contractors during similar projects in the St. Louis District, but does not include overhead, mobilization, and other related costs that NUREG-1727 allows to be considered in an ALARA analysis. The estimated cost of excavation, transportation, and disposal of the remaining elevated areas is approximately $6,300. This cost assumes that a surface area of 46 m^2 would be excavated to a depth of 1 foot (0.3 meters) below ground surface at a unit cost of approximately $460/cubic meter. The unit cost is based only on the cost elements of excavation, transportation and disposal as included in Appendix B and the total soil removed (i.e., 51 bank $yard^3$). The cost of further remediation greatly exceeds the economic benefit of the averted dose, therefore the action is considered ALARA.

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