REVISION B

# REMEDIAL INVESTIGATION AND BASELINE RISK ASSESSMENT REPORT FOR THE INACCESSIBLE SOIL OPERABLE UNIT AT THE ST. LOUIS DOWNTOWN SITE

## ST. LOUIS, MISSOURI

NOVEMBER 10, 2011


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

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*prepared by:*
U.S. Army Corps of Engineers, St. Louis District Office
Formerly Utilized Sites Remedial Action Program

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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| Ac-227 | actinium-227 |
| AEC | Atomic Energy Commission |
| ALM | Adult Lead Methodology (model) |
| amsl | above mean sea level |
| ARAR | applicable or relevant and appropriate requirement |
| bgs | below ground surface |
| BNSF | Burlington-Northern Santa Fe |
| BRA | baseline risk assessment |
| BV | background value |
| C-T | Columbium-Tantalum |
| CDI | chronic daily intake |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| *CFR* | *Code of Federal Regulations* |
| cm | centimeter |
| COC | contaminant of concern |
| COPC | contaminant of potential concern |
| cpm | counts per minute |
| CR | cancer risk |
| CSF | cancer slope factor |
| CSM | conceptual site model |
| DAD | dermally absorbed dose |
| DCGL | derived concentration guideline level |
| DOD | U.S. Department of Defense |
| DOE | U.S. Department of Energy |
| dpm | disintegrations per minute |
| DQO | data quality objective |
| DSR | dose-to-source ratio |
| EC | exposure concentration |
| ERAGS | Ecological Risk Assessment Guidance for Superfund |
| EPC | exposure point concentration |
| FFA | Federal Facility Agreement |
| FGR | Federal Guidance Report |
| FOD | frequency of detection |
| FS | feasibility study |
| FSS | final status survey |
| FSSE | final status survey evaluation |
| FSSP | final status survey plan |
| ft | foot |
| FTP | Field Technical Procedure |
| FUSRAP | Formerly Utilized Sites Remedial Action Program |
| GI | gastrointestinal |
| GIS | geographic information system |
| GOF | goodness of fit |
| GPS | global positioning system |
| GWS | gamma walkover survey |
| HHRA | human health risk assessment |
| HI | hazard index |

## LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

| | |
|---|---|
| HISS | Hazelwood Interim Storage Site |
| HQ | hazard quotient |
| hr | hour |
| HU | hydrostratigraphic unit |
| ICP | Inductively Coupled Plasma |
| IDW | investigation-derived waste |
| in | inch(es) |
| IRIS | Integrated Risk Information System |
| ISOU | Inaccessible Soil Operable Unit |
| IUR | inhalation unit risk |
| LCS | laboratory control sample |
| LOAEL | lowest observed adverse effects level |
| m | meter |
| MDA | minimum detectable activity |
| MDC | minimum detectable concentration |
| MDL | method detection limit |
| MDNR | Missouri Department of Natural Resources |
| MED | Manhattan Engineer District |
| mg/kg | milligrams per kilogram |
| mg/L | milligrams per liter |
| mi | mile |
| mrem/yr | millirem per year |
| MSD | Metropolitan St. Louis Sewer District |
| N/A | not applicable |
| NAD | normalized absolute difference |
| NaI | sodium-iodide |
| NC | North St. Louis County |
| NCP | *National Oil and Hazardous Substances Contingency Plan* |
| NOAEL | no observed adverse effects level |
| NORM | naturally occurring radioactive material |
| NRC | U.S. Nuclear Regulatory Commission |
| ORP | oxidation-reduction potential |
| OU | operable unit |
| % | percent |
| Pa-231 | protactinium-231 |
| PAH | polycyclic aromatic hydrocarbons |
| Pb-210 | lead-210 |
| pCi/g | picocuries per gram |
| pCi/m$^2$ | picocuries per square meter |
| PCOC | potential contaminant of concern |
| PDI | pre-design investigation |
| PRAR | post-remedial action report |
| QA | quality assurance |
| QAPP | Quality Assurance Project Plan |
| QC | quality control |
| QCSR | Quality Control Summary Report |
| Ra-226 | radium-226 |

## LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

| | |
|---|---|
| Ra-228 | radium-228 |
| RAGS | Risk Assessment Guidance for Superfund |
| RAO | remedial action objective |
| RCRA | Resource Conservation and Recovery Act |
| redox | oxidation-reduction |
| RESRAD | Residual Radioactivity (model) |
| RfC | reference concentration |
| RfD | reference dose |
| RG | remediation goal |
| RI | remedial investigation |
| Rn-222 | radon-222 |
| ROD | record of decision |
| ROW | right-of-way |
| RPD | relative percent difference |
| RR | railroad |
| RSL | regional screening level |
| SAG | Sampling and Analysis Guide |
| SAIC | Science Applications International Corporation |
| SARA | Superfund Amendments and Reauthorization Act |
| SF | slope factor |
| SLDS | St. Louis Downtown Site |
| SLS | St. Louis Sites |
| $SOR_N$ | sum of ratios (net) |
| SQL | sample quantitation limit |
| SQL/2 | one-half the reported sample quantitation limit |
| SVOC | semivolatile organic compound |
| T&E | threatened and endangered |
| Th-228 | thorium-228 |
| Th-230 | thorium-230 |
| Th-232 | thorium-232 |
| U-234 | uranium-234 |
| U-235 | uranium-235 |
| U-238 | uranium-238 |
| UCL | upper confidence limit |
| $UF_4$ | uranium tetrafluoride (green salt) |
| UNH | uranyl nitrate hexahydrate |
| $UO_2$ | uranium oxide |
| $UO_3$ | uranium trioxide |
| URO | unreacted ore |
| USACE | U.S. Army Corps of Engineers |
| USEPA | U.S. Environmental Protection Agency |
| UTL | upper tolerance limit |
| VCP | vitrified clay pipe |
| VOC | volatile organic compound |
| VP | vicinity property |
| WP | work plan |

# EXECUTIVE SUMMARY

This Remedial Investigation (RI) and Baseline Risk Assessment (BRA) Report for the Inaccessible Soil Operable Unit (ISOU) at the St. Louis Downtown Site (SLDS) was developed in support of the Formerly Utilized Sites Remedial Action Program (FUSRAP).The SLDS is located in an industrial area in the eastern portion of the city of St. Louis, just west of the Mississippi River. The SLDS is comprised of approximately 210 acres of land, which includes the former Mallinckrodt property and 38 surrounding vicinity properties (VPs). The former Mallinckrodt property comprises approximately 44.5 acres of land, where uranium was processed for the nation's early atomic weapons development program conducted under the Manhattan Engineer District (MED) and the U.S. Atomic Energy Commission (AEC). The 38 surrounding VPs comprise over 165 acres of land. The former Mallinckrodt property and the surrounding properties have the potential for radiological and chemical contamination as a result of the historic MED/AEC operations and/or subsequent transportation, storage, or migration of MED/AEC-related residues. The RI areas for the ISOU include:

- Former Mallinckrodt Plants 1, 2, 3, 6, 7, 8, 9, and 11; and
- 38 VPs [i.e., DT-1 through DT-37 and the Terminal Railroad (RR) Soil Spoils Area].

The RI activities generated data, which when combined with applicable existing data, provided sufficient information to assess risks to various receptors within the ISOU. RI activities included a review of the available history and usage of the sites, development of potential contaminants of concern (PCOCs), inaccessible soil sampling, gamma walkover surveys (GWSs), radiological surveys of structures, sewer investigations, contaminant risk evaluation, and development of this RI/BRA report.

## PURPOSE AND SCOPE

The purpose of this RI and BRA is to define the nature and extent of MED/AEC soil contamination present in the ISOU and assess the associated risk to human health and the environment under the current and reasonably anticipated future land use (industrial/commercial in an urban setting) for the SLDS. The results of this RI and BRA will be used to determine if MED/AEC-related contaminants are present at concentrations sufficiently low to be fully protective of human health and the environment.

The *Record of Decision for the St. Louis Downtown Site* (1998 ROD) (USACE 1998a) addressed accessible soil contamination and ground-water contamination. The scope of the ISOU includes all media not covered by the 1998 ROD that may have become contaminated as a result of the deposition or migration of MED/AEC-related contaminated media. Specifically, these media include the following:

- Soil that is inaccessible due to the presence of buildings and other permanent structures, including the supporting subsoil within the footprint of a structure of which remediation would reasonably be expected to affect the stability of the structure.
- Soil located under active railroads (RRs), including the supporting soil in the associated right-of-way (ROW).
- Soil located under roadways, including the supporting soil in the associated ROW. Roadways are defined as the public and private streets. Inaccessible soil does not include soil beneath driveways, parking lots, or other paved surfaces that were addressed as accessible soil areas.

- Soil on the exteriors and interiors of buildings and permanent structures (e.g., tanks, bridges, sheds, loading docks, utility poles, traffic signals, piping, rail tracks, and equipment boxes).
- Sewers (e.g., structures and interior sediment) not directly encountered within an excavation area during the remedial action conducted under the 1998 ROD.
- Soil adjacent to sewers located beneath buildings, permanent structures, RRs, and/or roads.

During preparation of the *Remedial Investigation Work Plan for the Inaccessible Soil Operable Unit at the St. Louis Downtown Site* (USACE 2009a) [hereafter referred to as the RI Work Plan (WP)], detailed reviews of historical usage of the SLDS areas within the scope of this RI were conducted in order to determine appropriate PCOCs. In addition, several characterization studies of various media (i.e., soil, sediment, ground water, sewers, and buildings) have been conducted at the SLDS since 1977. The existing characterization data and the results of the *Baseline Risk Assessment for Exposure to Contaminants at the St. Louis Site* (hereafter referred to as the 1993 BRA; DOE 1993) were used during development of the work plan to streamline the data needs for this RI.

Data collected from pre-design investigations (PDIs) and final status surveys (FSSs) conducted as part of the remediation activities for accessible soil was also useful in determining potentially contaminated inaccessible soil areas or structures. In addition, data resulting from ongoing investigations in support of the remediation of accessible soil have been used to supplement, modify, or amend RI sampling, as appropriate.

The PCOCs determined for the ISOU were identified based on the results of previous investigations and include the primary radioactive contaminants in soil and sediment. These are: radium-226 (Ra-226), radium-228 (Ra-228), thorium-228 (Th-228), thorium-230 (Th-230), thorium-232 (Th-232), uranium-238 (U-238), and uranium-235 (U-235) and its decay products [including actinium-227 (Ac-227) and protactinium-231 (Pa-231)] (USACE 1998a). Uranium-bearing ores that were processed for MED/AEC may have contained elevated levels of some metals. For the inaccessible soil within the uranium-ore processing area, the metal PCOCs are those that were identified as contaminants of concern (COCs) for accessible soil in the 1998 ROD (i.e., arsenic, cadmium, and uranium metal) (USACE 1998a). Because sediment present in the drains, manholes, and sewers used for MED/AEC operations had not been analyzed for metals during past investigations, metals associated with formerly used pitchblende and domestic ores (i.e., arsenic, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, vanadium, zinc, and uranium metal) were identified as PCOCs for sampling and analysis of sewer sediment and soil adjacent to sewers.

## FIELD ACTIVITIES AND FINDINGS OF THE REMEDIAL INVESTIGATION

As described in Section 2.0 of this report, a variety of field investigation methods were utilized to evaluate the presence of potential contaminants for areas within the scope of this RI. Primary investigation methods consisted of:

Radiological Structure Surveys: Structures with the potential for MED/AEC-related radiological soil contamination were surveyed. Radiological surveys included scanning for total alpha and beta surface activity and obtaining fixed-point measurements for total alpha and beta surface activity using portable radiological survey equipment. Building and structure surfaces that were surveyed included roofs, exposed exterior and interior surfaces, air vents, vertical and horizontal piping, and piping supports. The scoping surveys were biased, focusing on areas that are prone to accumulate contamination such as horizontal surfaces, depressions, cracked surfaces, rusted or unpainted surfaces, intake and exhaust vents, etc.

*Inaccessible Surface and Subsurface Soil Sampling*: GWSs were conducted in indoor and outdoor areas that had the potential for MED/AEC-related radiological soil contamination. GWSs were conducted using a sodium-iodide (NaI) gamma scintillation detector coupled with a global positioning system (GPS) unit in order to record both gamma radiation readings and geographic position data. Surveys were focused on inaccessible soil areas beneath buildings, permanent structures, roads, and RRs and the results were used to identify biased soil sample locations.

Soil sampling was conducted in the inaccessible soil areas to determine the extent of PCOC contamination. Soil investigations were conducted at random, biased, and/or systematic soil sampling locations in inaccessible areas. Soil investigations consisted of surface (typically below ground cover) and subsurface soil sampling for radiological and chemical PCOCs. All soil samples were analyzed for radionuclides and soil samples from some locations within the uranium-ore processing area were also analyzed for metals.

*Sewer Investigation*: Soil and sediment samples associated with sewers were collected and analyzed to obtain sufficient and representative data to determine the extent of radiological and metals contamination associated with sewers. Specifically, the following types of samples were collected:

- sediment samples from manholes and surface drains (grate inlets), and
- soil samples from areas adjacent to sewer lines.

The investigation included sewers that were used for MED/AEC operations as well as sewers that could contain MED/AEC contamination due to receiving runoff from contaminated areas. Sediment sampling was conducted in manholes located upstream (west) of the Mallinckrodt facility to provide a background dataset for determining site-specific sediment background values. Sediment and soil samples were analyzed for the metal and radionuclide PCOCs.

Section 4.0 of this report presents the findings of the RI field activities. Analytical results generated for each PCOC in each media during the RI field activities were compared to appropriate screening values as presented in the RI WP (USACE 2009a). Radiological screening levels are dose-based and metals screening levels are risk-based. Concentrations below screening levels are unlikely to cause any health risks following exposure. PCOCs with concentrations exceeding their screening levels were subsequently defined as contaminants of potential concern (COPCs).

The COPCs include all the radiological PCOCs for inaccessible soil areas, buildings, and soil adjacent to sewers, and the metals arsenic and cadmium for inaccessible soil areas beneath or adjacent to RRs; arsenic, cadmium and lead for soil adjacent to sewers; and arsenic and cadmium in sewer sediment. Generally, the transport pathways expected to be significant in the migration of these COPCs within or away from ISOU sources include air transport, ground-water transport, and surface-water runoff. Table ES-1 summarizes the constituents that exhibited analytical results above appropriate human health screening values in each media. These COPCs were carried forward for quantitative evaluation in the BRA to determine human health carcinogenic and noncarcinogenic risks.

## Table ES-1. Summary of Screening Value Exceedances

| Property | Specific Location | ISOU Media | | | |
|---|---|---|---|---|---|
| | | Inaccessible Soil | Building/ Structural Surfaces | Sewers | |
| | | | | Sewer Sediment | Soil Adjacent to Sewer |
| Plant 1 | Building 25 | Radiological | Radiological | - | - |
| | Area Beneath Building 26 | Radiological | - | - | - |
| | Two Areas Beneath Building X | Radiological | - | - | - |
| | Four Areas at Building 8 | Radiological | - | - | - |
| | Three Inaccessible Soil Areas Adjacent to Building K Excavation Area | Radiological | - | - | - |
| | Inaccessible Soil Area North of Southeast Containment Pad | Radiological | - | - | - |
| | Inaccessible Soil Area South of Building X Loading Dock | Radiological | - | - | - |
| | Between Buildings G and 17 | - | - | - | Radiological, As, Cd, Pb |
| | Various Sewer Sediment Locations | - | - | As, Cd | - |
| | Various Sewer Borehole Locations | - | - | - | As, Cd, Pb |
| Plant 2 | Building 508 | Radiological | - | - | - |
| | Area at northwest end of 50-series Building Excavation | Radiological | | | |
| | Inaccessible Soil Area North of Building 510 (and South of the 50-Series Buildings Excavation). | Radiological | - | - | - |
| | Southeast Corner | Radiological | - | - | - |
| | Various Sewer Sediment Locations | - | - | As | - |
| | One Sewer Borehole Location | - | - | - | Pb |
| Plant 6 | Inaccessible Areas at the Southwest Corner Adjacent to Destrehan Street | Radiological | - | - | - |
| | Along Hall Street, West of Plant 6 | Radiological | - | - | |
| | Sewer Beneath Hall Street at Northwest Corner of Plant 6WH | - | - | - | Radiological |
| | Sewer Sediment Locations | - | - | As | - |
| | Soil Location South of Plant 6WH adjacent to Sewer Line | - | - | - | Pb |
| St. Louis City Property (DT-2) | Levee South Area (East of Adjacent Plant 7E and DT-1) | Radiological | - | - | - |
| | Levee Area South of the McKinley Bridge | Radiological | - | - | - |
| | Sewers Beneath the Levee | - | - | - | Radiological |

## Table ES-1. Summary of Screening Value Exceedances (Continued)

| Property | Specific Location | ISOU Media | | | |
|---|---|---|---|---|---|
| | | Inaccessible Soil | Building/ Structural Surfaces | Sewers | |
| | | | | Sewer Sediment | Soil Adjacent to Sewer |
| Gunther Salt (DT-4) North | Salt Dome Area and Northeast Corner of Southern Storage Building | Radiological | - | - | - |
| | Southern Storage Building | Radiological | - | - | - |
| | Sidewalk along Buchanan Street | Radiological | | | |
| | Areas Within and Adjacent to Administration/Warehouse Building | Radiological | - | - | - |
| Heintz Steel (DT-6) | Areas Beneath Storage Building | Radiological | - | - | - |
| | Inaccessible Area at Western Edge of Storage Building Along Hall Street | Radiological | - | - | - |
| PSC Metals, Inc. (DT-8) | North Tract 3 – RR Tracks Area | Radiological | - | - | - |
| | North Tract 4 – RR Tracks Area | Radiological | - | - | - |
| | South Tract – Southeast Corner of Warehouse | Radiological | - | - | - |
| Thomas and Proetz Lumber Company (DT-10) | Office Building | As | - | - | - |
| | Wood Storage Building | - | Radiological | - | - |
| Illinois Department of Transportation and Missouri Department of Transportation (DT-11) | Sewer Sediment Location | - | - | As | - |
| Cotto-Waxo Company (DT-14) | A small area on a metal beam at roof level of the L-shaped Building | - | Radiological | - | - |
| Norfolk Southern RR (DT-3) | Hot Spot East of Plant 10 and South of Destrehan Street | Radiological | - | - | - |
| | Hot Spot Between Mallinckrodt and Destrehan Streets | Radiological | - | - | - |
| Terminal RR Association (DT-9) Rail Yard | Three Areas in the Rail Yard (Two on the Northern RR Track and One on the RR Track Traversing Southwest to Northeast) | Radiological | - | - | - |
| Terminal RR Association (DT-9) Main Tracks | Three Areas Between the McKinley Bridge and Destrehan Street | Radiological<br>Cd | - | - | - |
| Terminal RR Soil Spoils Area | Small Area at the Southern End of the Norfolk Southern RR Spur in the Northern Portion of the Property, and Two Isolated Areas Along the Terminal RR Tracks | Radiological | - | - | - |

**Table ES-1. Summary of Screening Value Exceedances (Continued)**

| Property | Specific Location | ISOU Media | | | |
|---|---|---|---|---|---|
| | | Inaccessible Soil | Building/ Structural Surfaces | Sewers | |
| | | | | Sewer Sediment | Soil Adjacent to Sewer |
| Burlington Northern Santa Fe (BNSF) RR (DT-12) | One Area North of the McKinley Bridge, East and adjacent to DT-9 Rail Yard | Radiological | - | - | - |
| | Large Area on the West side of Tracks Extending from Just North of Destrehan Street South to Dock Street | Radiological, As | - | - | - |
| | Sewers Northeast of Plant 7N Beneath BNSF RR tracks | - | - | - | Radiological, Cd |
| Hall Street | West of Plant 6 | Radiological | - | - | - |
| North Second Street | West of Plant 1 | Radiological | - | - | - |
| Mallinckrodt Street | North of Plant 2 | Radiological | - | - | - |
| Destrehan Street | West of Hall Street | Radiological | - | - | - |
| Angelrodt Street | South of Plant 7S | Radiological | - | - | - |

Note: Radiological COPCs were identified by exceedance of $SOR_N > 1.0$, and always include the following: Ac-227, Pa-231, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-235, and U-238. Metals were identified as COPCs if they exceed the industrial risk-based screening level. Dashes indicate no COPCs are identified for the area and medium.
As – arsenic
Cd – cadmium
Pb – lead

## BASELINE RISK ASSESSMENT

As summarized in Section 6.0, a BRA was performed to estimate current and potential future dose and risks to human and ecological receptors that could result from exposures to radiological and metals COPCs in inaccessible soil and sewer sediment that were not addressed in the 1998 ROD (USACE 1998a). The BRA consists primarily of two components: a quantitative human health risk assessment (HHRA) and a qualitative ecological assessment, the summaries and findings of which are discussed below.

### Human Health Risk Assessment

The BRA was completed assuming no remedial actions would be completed and no institutional or engineering controls would be maintained or established. The HHRA identified ISOU media and site properties that exhibit dose and/or risk exceeding target criteria of 25 millirem per year (mrem/yr) and a cancer risk (CR) of 1 in 100,000 (1.0E-05), assuming the inaccessible soils become accessible.

Those COPCs that individually exceed target criteria were identified as COCs for evaluation in the Feasibility Study (FS). None of the exterior building surfaces or sediments in sewer lines exceeded dose or risk criteria and, therefore, are not retained for further evaluation in the FS. Based on the HHRA results, the following are properties/areas, potential human receptors, and COCs being retained for further evaluations in the FS.

*Inaccessible Soil at Plant Properties and Industrial/Commercial VPs*: The following plant properties and industrial/commercial VPs exceeded dose/risk criteria for industrial worker evaluations:

- Plant 1 – Radiological COCs
- Plant 6 – Radiological COCs

- St. Louis City Property (DT-2) – Radiological COCs
- Gunther Salt (DT-4) North – Radiological COCs
- Heintz Steel (DT-6) – Radiological COCs

*Inaccessible Soil at Railroad Properties and Roadways*: The following RR properties and roadways exceeded risk criteria for industrial worker evaluations:

- *Railroad VPs*:
  - Norfolk Southern RR (DT-3) – Radiological COCs
  - Terminal RR (DT-9) Main Tracks – Radiological COCs
  - Terminal RR (DT-9) Rail Yard – Radiological COCs
  - Terminal RR Soil Spoils Area – Radiological COCs
  - Burlington Northern Santa Fe (BNSF) RR (DT-12) – Radiological COCs and arsenic
- *Roadways*:
  - Hall Street (West of Plant 6) – Radiological COCs
  - North Second Street (West of Plant 1) – Radiological COCs
  - Mallinckrodt Street (North of Plant 2) – Radiological COCs
  - Destrehan Street (West of Hall Street) – Radiological COCs
  - Angelrodt Street (South of Plant 7S) – Radiological COCs

*Inaccessible Soil in Elevated Measurement Areas*: The following property exceeded dose/risk criteria for utility worker evaluations:

- Plant 1, Building 26 – Radiological COCs

*Inaccessible Soil Adjacent to Sewer Lines*: Several soil borings and soil samples associated with previous accessible sewer line excavations exceeded dose/risk criteria for sewer utility worker exposures to radiological COPCs in inaccessible soil adjacent to sewer lines. All CRs and Hazard Indices (HIs) estimated for metal COPCs were below target criteria. However, lead was evaluated differently than other metals based on U.S. Environmental Protection Agency (USEPA) guidance. Lead is considered to be a COC in inaccessible soil areas near sewers at concentrations exceeding USEPA's industrial soil Regional Screening Level (RSL) of 800 milligrams/kilogram (mg/kg). Therefore, the following areas are being retained for further evaluation in the FS:

- Plant 1, Boreholes SLD124540 (Radiological COCs and Lead), SLD124560 (Lead), and SLD124570 (Lead)
- Plant 2, Borehole SLD124576 – Lead
- Plant 6, Sewer Line in Northwest Corner of Property, beneath Hall Street – Radiological COCs
- Plant 6, Borehole SLD127572 – Lead
- St. Louis City Property (DT-2), Sewer Beneath the Levee – Radiological COCs
- Plant 7N/BNSF RR (DT-12), Sewer Beneath the RR tracks – Radiological COCs

A qualitative ecological assessment was conducted based on the environmental assessment of biota conducted for accessible media in the 1993 BRA (DOE 1993) and the findings of a September 10, 2010, site visit that documented the environmental setting, potential receptors, contaminant fate and transport, and exposure pathways per USEPA guidance (1997c). USACE concurs with the findings of the 1993 ecological evaluation that potential impacts to ecological receptors from ISOU media are likely to be insignificant. Given that some remediation at the SLDS has been conducted since 1993, potential impacts to ecological resources from the ISOU contaminated media are likely to be less significant than determined during the 1993 BRA. As a result of the qualitative ecological assessment findings, the ISOU BRA does not include a comprehensive ecological risk assessment.

# 1.0 INTRODUCTION

This Remedial Investigation (RI) and Baseline Risk Assessment (BRA) Report for the Inaccessible Soil Operable Unit (ISOU) at the St. Louis Downtown Site (SLDS) was developed in support of the Formerly Utilized Sites Remedial Action Program (FUSRAP). In 1974, the U.S. Atomic Energy Commission (AEC) [later to become the U.S. Department of Energy (DOE) and the U.S. Nuclear Regulatory Commission (NRC)] established the FUSRAP to address sites, such as the SLDS, that were contaminated as a result of the nation's early atomic weapons development program.

The SLDS is one of two separate geographical areas collectively referred to as the St. Louis Sites (SLS). These two areas are comprised of multiple properties and are located in two distinct areas: the city of St. Louis and North St. Louis County (NC) (Figure 1-1). These two areas are designated as the SLDS and the NC sites, respectively. This RI/BRA applies only to the SLDS ISOU.

The SLDS is located in an industrial area in the eastern portion of the city of St. Louis, just west of the Mississippi River. The SLDS consists of an active chemical processing facility and additional tracts of land called vicinity properties (VPs) (Figure 1-2). The chemical processing facility was formerly used to process uranium for the Manhattan Engineer District (MED) and the AEC and was previously owned and operated by Mallinckrodt Chemical Works, Inc. and Mallinckrodt, Inc. but is now owned and operated by Covidien. For the purpose of this RI/BRA Report, the chemical plant property will be referred to by its historic designation as the "Mallinckrodt" plant area or property. The SLDS VPs consist of 37 numbered properties and one unnumbered property surrounding the Mallinckrodt property with potential radiological and metals contamination as a result of the historic MED/AEC operations and/or subsequent transportation, storage, or migration of MED/AEC-related residues.

## 1.1 PURPOSE

In 1980, Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Public Law 96-510), also known as "Superfund," which was created to remedy threats to human health and the environment from releases of hazardous wastes from various industries. In 1986, CERCLA was reauthorized and amended by the Superfund Amendments and Reauthorization Act (SARA) requiring federal facilities to abide by the same CERCLA requirements. Response actions at FUSRAP sites are subject to the administrative, procedural, and regulatory provisions of CERCLA.

The CERCLA process includes the investigation, evaluation, and documentation of the contaminants present at a site or portions of a site (the RI); an assessment of the potential risks to human health and the environment posed by those contaminants (the BRA); and, if necessary, assessment screening and detailed evaluation of potential remedial alternatives for reducing unacceptable risk [a Feasibility Study (FS)]. Based upon the results of the RI/BRA/FS process, a Proposed Plan is developed, and a remedial decision is documented in a Record of Decision (ROD).

In accordance with 40 *Code of Federal Regulations (CFR)* 300.430(a)(ii)(A), the CERCLA process may be completed in operable units (OUs) when phased analysis and response is necessary or appropriate given the size or complexity of the site or to expedite site cleanup. The *Record of Decision for the St. Louis Downtown Site* (hereafter referred to as the 1998 ROD; USACE 1998a), addressed accessible soil and ground-water contamination as one OU. The

ISOU includes soil and sediment at SLDS not addressed by the 1998 ROD that have the potential for MED/AEC contamination, as described in Section 1.1.2.

The purpose of this RI and BRA is to define the nature and extent of MED/AEC soil contamination present in the ISOU and assess the associated risk to human health and the environment under the current and reasonably anticipated future land use (industrial/commercial in an urban setting) for the SLDS. The results of this RI and BRA will be used to determine if MED/AEC-related contaminants are present at concentrations sufficiently low to be fully protective of human health and the environment.

### 1.1.1 Regulatory Overview

In 1974, AEC established FUSRAP for the cleanup of sites contaminated from past activities involving radioactive materials. Because contamination related to MED/AEC activities was present at the SLDS at levels that required a response, the SLDS was designated for inclusion under FUSRAP. At that time, one OU was established for the SLS.

In June 1990, a Federal Facility Agreement (FFA) for the SLS was established between the DOE and U.S. Environmental Protection Agency (USEPA) Region VII (DOE 1990). This agreement, pursuant to CERCLA Section 120, Federal Facilities, defined implementation and oversight roles for the respective agencies involved in the CERCLA process. The FFA stated that DOE would conduct response actions at the SLS for the following materials:

- All wastes, including but not limited to radiologically contaminated wastes, resulting from or associated with, MED/AEC uranium manufacturing or processing activities conducted at the SLDS; and
- Other chemical or non-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 (DOE 1990).

DOE managed FUSRAP until October 1997 when responsibility for the execution of the program was transferred to the U.S. Army Corps of Engineers (USACE) under the Fiscal Year 1998 Energy and Water Appropriations Act. Consistent with the transfer of authority, USACE is the lead agency responsible for response actions at the SLDS. DOE will assume a stewardship responsibility beginning two years after completion of the response actions at the SLDS.

Between 1989 and 1993, the RI/BRA for the SLS was conducted and included the sampling of accessible and inaccessible soil, buildings, sewers, surface water, sediment, and ground water at both the NC site and the SLDS. The *Baseline Risk Assessment for Exposure to Contaminants at the St. Louis Site* (hereafter referred to as the 1993 BRA; DOE 1993) concluded that radiologically contaminated soil at the SLDS was the source of cancer risks (CRs) in excess of USEPA's CERCLA target CR range of 1 in 1,000,000 to 1 in 10,000 (i.e., 1E-06 to 1E-04) under current industrial and future land use scenarios. Based on these results, remedial action was judged to be warranted at the SLDS.

In 1991, the *Engineering Evaluation/Cost Analysis for Decontamination at the St. Louis Downtown Site* (DOE 1991) evaluated potential removal actions at the SLDS. In 1992, the *Action Memorandum for the Removal of Contaminated Materials at the St. Louis Downtown Site, St. Louis, Missouri* (DOE 1992) was issued to address four removal actions involving the demolition of several buildings at the Mallinckrodt Plant area remaining from MED/AEC operations. When the *Feasibility Study for the St. Louis Downtown Site* (USACE 1998b) (hereafter referred to as the 1998 FS) was published in 1998, it stated that the inaccessible soil beneath buildings and other permanent structures would be addressed as a subsequent CERCLA action because the inaccessible soil did not present a significant threat in its current configuration and "remediation of these soils at this time would result in severe economic dislocations and community disruptions" (USACE 1998b).

The 1998 ROD was published by USACE in consultation with USEPA and with concurrence from the Missouri Department of Natural Resources (MDNR). It defined remedial actions for accessible soil at the Mallinckrodt property and VPs, plus ground water beneath the SLDS for MED/AEC-related hazardous substances. The selected remedy for accessible soil was Alternative 6, Selective Excavation and Disposal. Accessible soil is defined in the 1998 ROD as soil that is not beneath buildings or other permanent structures. Long-term monitoring was required for ground water beneath the site. The 1998 ROD also stated that contaminated sediment in sewers and drains considered accessible would also be remediated (USACE 1998a).

The principal risk identified in the 1998 ROD was exposure to radioactivity remaining from past MED/AEC operations. The radiological contaminants of concern (COCs) defined by the 1998 ROD were uranium-235 (U-235), uranium-238 (U-238), radium-226 (Ra-226), radium-228 (Ra-228), thorium-228 (Th-228), thorium-230 (Th-230), thorium-232 (Th-232), actinium-227 (Ac-227), and protactinium-231 (Pa-231). The metal COCs applicable for soil inside the uranium-ore processing area of the SLDS were identified as arsenic, cadmium, and uranium metal. Soil remediation goals (RGs) for the radiological COCs identified in the 1998 ROD were consistent with applicable or relevant and appropriate requirements (ARARs) identified in accordance with CERCLA. RGs for metal COCs were developed based on site-specific risk-based values in accordance with CERCLA.

In March 2005, the *Memorandum for Record: Non-Significant Change to the Record of Decision for the St. Louis Downtown Site* was published, which provided specific clarifications regarding the delineation of the SLDS boundary (USACE 2005a). Additional VPs were determined to be impacted by MED/AEC wastes from the SLDS. In addition, certain property boundaries and, in some cases, the associated property owners, differed from those originally identified in the 1998 ROD. The following specific revisions were stated in the Memorandum for Record:

- Designating VPs by assigning property-specific alphanumeric identification numbers to clearly identify each property and to minimize confusion resulting from changing property ownership (e.g., DT-2, etc.) (Table 1-1).
- Modifying some VP boundaries due to changes in property boundaries after issuance of the 1998 ROD.
- Clarifying that contaminated soil under active rail lines on the three "Railroad Properties" is inaccessible and will be addressed as part of the ISOU.
- Clarifying that the 1998 ROD "specifically includes the Remediated Levee Property east of the levee but excludes contamination present beneath the existing levee, which will be addressed as part of the future ISOU" (USACE 2005a).
- Amending the SLDS boundaries "to increase the geographical area/scope of the SLDS site to include additional areas to the north, south, and west of the site" (USACE 2005a).
- Adding the Terminal Railroad (RR) Soil Spoils Area, located south of the SLDS, to the amended geographical area of the SLDS.

**Table 1-1. St. Louis Downtown Site Vicinity Properties**

| Current Property Name | VP Number |
|---|---|
| Kiesel (formerly Archer Daniels Midland and PVO Foods)[a] | DT-1 |
| St. Louis City Property | DT-2 |
| Norfolk Southern RR (formerly Norfolk and Western RR) | DT-3 |
| Gunther Salt (North and South) | DT-4 |
| AmerenUE | DT-5 |
| Heintz Steel and Manufacturing | DT-6 |
| Midwest Waste[a] | DT-7 |
| PSC Metals, Inc. (formerly McKinley Iron Works) | DT-8 |
| Terminal RR Association | DT-9 |
| Thomas and Proetz Lumber Company | DT-10 |
| Illinois Department of Transportation and the Missouri Department of Transportation (aka McKinley Bridge) (formerly the city of Venice, Illinois) | DT-11 |
| Burlington-Northern Santa Fe (BNSF) RR (formerly Chicago, Burlington, and Quincy RR) | DT-12 |
| Cash's Scrap Metal | DT-13 |
| Cotto-Waxo Company | DT-14 |
| Metropolitan St. Louis Sewer District (MSD) Lift Station | DT-15 |
| Star Bedding Company | DT-16 |
| Christiana Court, LLC | DT-17 |
| Curley Collins Recycling (currently owned by the city of St. Louis) | DT-18 |
| City of St. Louis Streets | DT-19 |
| Richey | DT-20 |
| Favre | DT-21 |
| Tobin Electric | DT-22 |
| InterChem | DT-23 |
| Bremen Bank | DT-24 |
| Eirten's Parlors | DT-25 |
| United Auto Workers Local 1887 | DT-26 |
| Dillon | DT-27 |
| Challenge Enterprise | DT-28 |
| Midtown Garage (currently owned by Cash's Scrap Metal) | DT-29 |
| ZamZow Manufacturing | DT-30 |
| Porter Poultry | DT-31 |
| Westerheide Tobacco[a, b] | DT-32 |
| Missouri Department of Transportation Roads | DT-33 |
| Hjersted | DT-34 |
| Factory Tire Outlet | DT-35 |
| OJM, Inc. | DT-36 |
| Lange-Stegmann | DT-37 |
| Terminal RR Soil Spoils Area | NA |

[a] These VPs are not included in the scope of this OU because no inaccessible soil areas or buildings and structures remain at the property.
[b] Property was purchased by Mallinckrodt, building was demolished, and area is now a parking lot at Plant 8.
NA = Not applicable.

The *Remedial Investigation Work Plan for the Inaccessible Soil Operable Unit at the St. Louis Downtown Site* (USACE 2009a) [hereafter referred to as the RI Work Plan (WP)] was finalized in November 2009 after regulatory review by USEPA and MDNR. The RI WP presented the sampling protocol for the ISOU based on an evaluation of data from characterization studies of various media (e.g., soil, sediment, sewers, and buildings) conducted at the SLDS since 1977. These studies provided a detailed understanding of the environmental setting and the nature of contamination at the SLDS. In addition, the data collected from 1977 to 1993 were used as part of the 1993 BRA to evaluate the human health and ecological risks associated with the impacted media at the SLDS, including both inaccessible and accessible soil. The existing characterization data and the results of the 1993 BRA were used to streamline the data needs for the ISOU RI.

Sampling for the ISOU RI began in June 2009 and ended in August 2010 with the majority of work being completed between October 2009 and May 2010. The results of the RI are detailed in this report.

### 1.1.2 Operable Unit Scope

The scope of the ISOU includes all media not covered by the 1998 ROD that may have become contaminated as a result of the deposition or migration of MED/AEC-related contaminated media.

Media within the scope of the ISOU include:

- Soil that is inaccessible due to the presence of buildings and other permanent structures, including the subsoil within the footprint of a structure of which remediation would reasonably be expected to affect the stability of the structure.
- Soil located under active RRs, including the supporting soil in the associated right-of-way (ROW).
- Soil located under roadways, including the supporting soil in the associated ROW. Roadways are defined as the public and private streets. Inaccessible soil does not include soil beneath driveways, parking lots, or other paved surfaces located at plant or VP areas that were addressed as accessible soil areas.
- Soil on the exteriors and interiors of buildings and permanent structures (e.g., tanks, bridges, sheds, loading docks, utility poles, traffic signals, piping, rail tracks, and equipment boxes).
- Sewers (e.g., structures and interior sediment) not directly encountered within an excavation area during the remedial action conducted under the 1998 ROD.
- Soil adjacent to sewers located beneath buildings, permanent structures, RRs, and/or roads.

The following properties are excluded from the scope of the ISOU:

- Plant 7E and three VPs (DT-1, DT-7, and DT-32) are excluded because they do not contain inaccessible soil areas and there are no sewers, buildings, or structures impacted by MED/AEC operations present at these properties. Accessible soil contamination has been remediated at Plant 7E and DT-7 to standards specified in the 1998 ROD. DT-1 and DT-32 did not require remediation.
- The inaccessible soil and structures at Plant 10 have been excluded because Plant 10 was remediated by DOE. The sewers used for MED/AEC operations at Plant 10 were included and evaluated in the RI WP and were determined to be non-impacted.
- Plant 5 is excluded because residual contamination is reasonably attributable to the Columbium-Tantalum (C-T) processing activities that were conducted at these areas by Mallinckrodt. C-T ores were processed by Mallinckrodt at Plant 5 under a separate NRC Source-Material License and therefore, remediation of this radiologically contaminated soil is not within the scope of FUSRAP. These ores contain natural uranium, thorium, and actinium decay series radionuclides.
- Plant 7W was used previously by MED/AEC and by Mallinckrodt for processing radioactive feed materials. Plant 7W is currently excluded from the ISOU because historic sources of contamination have not been determined.

The status of the following properties has changed since the publication of the RI WP and, therefore, the inclusion of the specific property areas within the scope of the ISOU has also changed.

- Soil at the north edge of the 50-series excavation area on Plant 2 was made available for remediation by the owner. After remediation of accessible soil under the 1998 ROD, inaccessible soil remaining will be evaluated as part of the ISOU. Further discussion of this property is presented in Section 4.2.2.
- Building 101 at Plant 6 is planned for demolition by USACE. Soil remaining within the footprint of Building 101 is considered accessible soil and is outside the scope of the ISOU. Further discussion of this property is presented in Section 4.2.3.
- Soil at the northeastern corner of Plant 7N was defined in the RI WP as an "inaccessible area of detected contamination" and was proposed for sampling as part of the ISOU. The subsurface soil beneath this area was found to be radiologically contaminated, presumably from sewer leakage. Because of the proposed remediation of Destrehan Street, this area at Plant 7N is proposed for accessible soil remediation under the 1998 ROD. Following the remediation, inaccessible soil remaining will be evaluated as part of the ISOU. Further discussion of this property is presented in Section 4.2.4.
- The Hazardous Waste Storage Area at Plant 7N was razed in 2010 and the associated soil and sewer lines remediated. Therefore, soil and sewer lines beneath this building are no longer defined as inaccessible and are outside the scope of the ISOU. Further discussion of this property is presented in Section 4.2.4.
- ROW soil along the Burlington-Northern Santa Fe (BNSF) RR (DT-12), was characterized during the RI, found to be radiologically contaminated, and then made available for remediation by the owner. Following the remediation, inaccessible soil remaining will be evaluated as part of the ISOU. Further discussion of this property is presented in Section 4.4.3.
- Soil beneath Destrehan Street, between Hall Street and the BNSF RR (DT-12), was characterized during the RI, found to be radiologically contaminated, and then made available for remediation by the owner. Following the remediation, inaccessible soil remaining will be addressed as part of the ISOU. Further discussion of this property is presented in Section 4.5.6.

## 1.2 SITE BACKGROUND

### 1.2.1 Location and General Site Description

The SLDS is located in an industrialized area on the eastern border of the city of St. Louis, just west of the Mississippi River (Figure 1-1). The SLDS consists of approximately 44.5 acres of the Mallinckrodt property, where MED/AEC activities were formerly conducted, and approximately 165 acres of surrounding VPs (Figure 1-2).

Mallinckrodt, Inc. became part of Covidien in 2007 and currently utilizes a number of plants (Plants 1 through 3 and 5 through 11) at the former Mallinckrodt facility. To maintain historic references, any actions taken prior to 2007 by the former Mallinckrodt, Inc. will be identified within this document as actions taken by Mallinckrodt. Similarly, any actions completed during and after 2007 will be identified as Covidien actions.

The Mallinckrodt property encompasses an area of approximately 12 city blocks roughly bounded by the McKinley Bridge on the north, Angelrodt Street on the south, North Broadway on the west, and BNSF RR (DT-12) on the east (Figure 1-2).

Thirty-seven numbered VPs and one unnumbered VP surrounding the Mallinckrodt property, which are identified in Table 1-1 and shown on Figures 1-1 and 1-2, are part of the SLDS. The VPs are identified using the prefix of DT to represent the "downtown" site and are followed by a number for consistent identification regardless of changing property ownership. Most of the VPs are small parcels of land owned by individuals conducting industrial, commercial, manufacturing, or retail businesses, including a lumber distributor, a scrap metal recycler, a bedding manufacturer, and a bank.

Some VPs are roadways owned either by the city of St. Louis or the Illinois and Missouri Departments of Transportation. The McKinley Bridge, which provides a vehicle transportation route over the Mississippi River between Illinois and Missouri, is owned by the Illinois Department of Transportation and the Missouri Department of Transportation (State of Illinois 2002).

There are three RR main lines or lead tracks traversing the SLDS in a north-south direction, each having an associated network of spur tracks and sidings (Figure 1-2). These RR lines are defined as VPs and include the Norfolk Southern RR (DT-3), the Terminal RR Association (DT-9), and the BNSF RR (DT-12).

Portions of the SLDS lie within the original floodplain of the Mississippi River. Such areas are now separated from the river by a levee and floodwall system identified as the St. Louis Flood Protection system. This system includes the Mississippi River levee, an earthen levee and concrete floodwall that protect St. Louis from Mississippi River floodwaters. The levee is present on VPs DT-2, DT-9, and DT-15. The St. Louis Riverfront Trail, a recreational bike trail, runs parallel to the Mississippi River along the Mississippi levee area (Figure 1-2). This recreational bike trail was constructed in 1997.

The Terminal RR Soil Spoils Area is the one unnumbered VP and is located approximately 650 feet (ft) south of the SLDS (Figure 1-1). This 16.7-acre property is located south of Dock Street and is bounded by Branch Street on the north, North Market Street on the south, Produce Row and a RR line continuing to the north to Branch Street on the west, and Grossman Iron and Steel Company on the east.

An extensive network of utility services exists at the SLDS, including sewers, sprinklers, city water lines, natural gas lines, overhead electricity and telephone lines, and overhead plant process pipes. Some of the sewers and subsurface utilities (e.g., electricity) are owned by municipal or public utility companies. Runoff from the SLDS is directed to a sewer system that discharges to a publicly owned treatment facility, which then discharges to the Mississippi River.

### 1.2.2 Operating History

Chemical production operations at the Mallinckrodt property began in 1867 when the original chemical plant was constructed, were continued during MED/AEC operations, and are ongoing by Covidien today. Historically, Mallinckrodt used, blended, and/or manufactured various chemicals at the site, including organic and inorganic compounds. Covidien currently manufactures pharmaceuticals, specialty chemicals, and other imaging products. Additionally, heavy industry and commercial processes have been performed throughout the SLDS vicinity for more than 100 years.

From 1942 to 1957, under contract to MED and AEC, Mallinckrodt processed uranium feed materials in support of the nation's early nuclear program. The contractual work from 1942 to 1947 was performed under MED. In 1947, the contract was transferred to the newly formed AEC and remained under AEC until operations ceased at the SLDS in 1957 (ORNL 1981).

The MED/AEC work conducted by Mallinckrodt included the development of uranium-processing techniques and the production of uranium metal. Processing of uranium ore was completed by digesting the ore in nitric acid to form uranyl nitrate, which was extracted with ether and water and denitrated by heating to produce uranium oxide ($UO_2$). Hydrofluoric acid was used to fluorinate the $UO_2$ to create uranium tetrafluoride ($UF_4$) (also referred to as "green salt"), which then was reduced with magnesium to produce uranium metal (DOE 1993). The main uranium ore processed for MED/AEC was African Congo pitchblende, though some domestic ores were also processed (DOE 1993). Early feed materials were relatively pure "black oxides," which had been extracted from uranium ores by other companies. Once stocks of "black oxides" were depleted, the plant began extracting uranium directly from uranium ores rather than merely purifying uranium from feed materials. In addition, some facilities were used for metallurgical processing of uranium and uranium recovery from metal slag (BNI 1990a). Process residuals, including radium, thorium, uranium, and their decay products, were inadvertently released into the environment. Uranium-bearing ores that were processed for MED/AEC may have contained elevated levels of some metals (e.g., arsenic, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, vanadium, or zinc) (USACE 1998a).

The MED/AEC work was conducted at Plants 1, 2, 6, 7, and 10 (formerly Plant 4) of the former Mallinckrodt Chemical Works. The historic layout of the MED/AEC and Mallinckrodt Plant Facility from 1958 is shown in Figure 1-3. Between 1942 and 1945, Plant 1 was used by MED/AEC for developmental work in refining triuranium octoxide feed and experimental processing of radium containing pitchblende ores. The MED/AEC work at Plant 1 was performed in four pre-existing Mallinckrodt structures; Buildings 25, A, K, and X. Developmental work at the laboratory level to support Plant 2 and Plant 10 operations took place in the second floor laboratory of Building 25 and in the alley between Buildings 25 and K. Additionally, experimental processing of radium-containing pitchblende ores, which began in the 1944-1945 timeframe, was conducted in the second floor laboratory of Building 25. The pilot plant to test radium-extraction methods was located in Building K and in the alley between Buildings 25 and K. Building 25 also contained the project offices. Building A was used for general plant maintenance, Building X housed locker rooms, and Buildings P and Z contained the engineering and other offices. Plant 1 was not used after 1945; the offices and laboratories moved to Plant 6.

Uranium refining operations began at Plant 2 in April 1942 producing approximately 4,400 tons of $UO_2$. Facilities for batch production were installed in Buildings 50, 51, 51A, 52 and 52A [the 50-series buildings] to produce uranium trioxide ($UO_3$) from ore concentrates. The concentrates were digested in nitric acid in Building 51 to produce uranyl nitrate, which was then transferred to Building 52 to be purified by ether extraction to uranyl nitrate hexahydrate (UNH). The UNH was converted in Building 51A first to $UO_3$ and then to $UO_2$. Building 50 was used as a warehouse to store incoming feed materials, outgoing product material and tanks of process liquids. Building 55 contained the laboratory that tested samples. In the spring of 1945, Building 52A was added to serve as a pilot plant for a continuous ether extraction process to replace the existing batch process. Work at Plant 2 ended in 1946 when the plant was closed and the work moved to the newly built Plant 6.

Late in 1942, Plant 10, a former sash and door works, was converted for uranium refining and dubbed "the metal plant". In 1943, production of green salts ($UF_4$) began at Plant 10. The metal production took place in Buildings 400 and 401B and the $UF_4$ production took place in Building 400 (Figure 1-3). Production of uranium metal was moved from Plant 10 to Plant 6E (now known as Plant 6EH) in 1946 and the $UO_2$ to $UF_4$ process was moved to Plant 7 in the 1951-1952 timeframe. Plant 10 was refitted as an experimental development and metallurgical pilot plant processing uranium metal; consequently, Plant 10 was thereafter referred to as the "pilot plant". The ingot metal production process was developed and conducted at Plant 10 in the mid-1950s, along with sporadic ordinary metal derby production on a developmental basis. Plant 10 was used by AEC until 1956.

In 1944, the government decided to build a new refinery to extract uranium from pitchblende ore. The new facility, called the Destrehan Street Facility (Plants 6, 6E, and 7), began operations in 1946. Plant 6 was built in 1945-1946 on a site fronting Destrehan Street and was then referred to as "the refinery". Most of the administrative offices, laboratories and support facilities for the uranium refining operations were located at Plant 6. The second new plant at the Destrehan Street site was Plant 7, the green salt plant. Construction included the 700-series buildings (703 to 708) which went into operation at sometime during 1951-1952 when the $UO_2$ to $UF_4$ process was moved from Plant 10 to Plant 7.

The pitchblende ore-to-$UO_2$ part of the refining process was moved to Plant 6 in early 1946 from Plant 2 along with the laboratory work from Plant 1. At that time, $UO_2$ production in the 50-series buildings at Plant 2 ceased (NPS 1997). The $UO_2$-to-metal production remained at Plant 10. The incoming ore arrived by rail and was stored in Building 110 at Plant 6 (Figure 1-3); however, in late 1950 an outdoor storage area was added for pitchblende ore. Building 104 processed mostly pitchblende ore and housed the continuous process equipment, which replaced the batch process equipment that had been used in Plant 2. In 1949, a second digest line was added in the building to process uranium ore concentrates. Most of the $UO_2$ produced at Plant 6 was trucked to Plant 10, with the rest going by rail to the Harshaw Chemical Company in Cleveland, OH and the Linde Ceramics Plant in Tonawanda, New York. When equipment was added to Plant 7 to allow continuous $UO_3$ to $UF_4$ conversion, Plant 6 began to produce only $UO_3$. Milling of $UO_3$ and pre-digestion ore grinding, both conducted at Plant 6, were discontinued in 1950 and 1955, respectively. Pitchblende ore continued to be used as feed until early 1955.

Plant 6E (now known as Plant 6EH), located to the east of Plant 6 (Figure 1-3) was built as the new metal plant, which went into operation in late 1950. Metal production ($UF_4$-to-U-metal) operations at Plant 10 moved to Plant 6E, which was then referred to as "the metal plant". Metal production took place in Building 116. Building 116C was built in 1954 to recycle magnesium fluoride slag.

At Plant 7, a continuous process replaced the batch-type process used at Plant 10 and later, equipment was added to allow for continuous production of $UF_4$ from $UO_3$ directly. Uranium metal recovery and some storage operations were moved to Plant 7 in 1952. Some reversion of $UF_4$ to $UO_2$ or $UO_3$ was done in 1954 and perhaps later. A new wet slag (interim residue) recovery operation was added in late 1955 in Building 701 as $UF_4$ was processed at Plant 7. Building 700 at Plant 7 was built in 1954 as a warehouse, with a portion of Building 700 used for machining of reactor cores (Mason 1977). Plant 7E (Figure 1-3), regarded administratively as part of Plant 7, was used from 1955-1957 to process pitchblende raffinate (solids removed during the uranium refining by wet filtration). Pitchblende raffinate was used to produce a concentrated Th-230 solution by an acid digestion process similar to the uranium ore digestion. The concentrate was sent to the Mound Site in Ohio for further processing. Some Plant 7 operations continued up to 1957 when they were transferred to the Weldon Spring Chemical Plant, in St. Charles County, Missouri.

When uranium processing operations began at the Mallinckrodt property, most of the streets and RRs now in existence at the SLDS had already been constructed. The raw material for the processing operations was transported to Mallinckrodt along the existing RRs. According to a February 15, 1945, memorandum titled *Shipment Security Survey at Mallinckrodt Chemical Works,* the raw materials were sent to the plant in sealed, individual containers such as metal containers, wood barrels and boxes, or fiber drums via sealed RR cars (Mallinckrodt 1945).

From 1948 to 1950, decontamination activities were conducted at Plants 1 and 2. The decontamination efforts were conducted to meet criteria in effect at that time, and the plants were released in 1951 for use without radiological restrictions. Operations at Plant 10 were terminated during 1955 and 1956 (ORNL 1981). Operations in Plants 6 and 7 ceased in 1957. Shutdown of all remaining MED/AEC operations at Mallinckrodt began in 1958. During 1961 and 1962, AEC managed the decontamination efforts at Plants 6 and 10, removing radiologically contaminated buildings, equipment, and soil. AEC also returned Plants 6 and 10 to Mallinckrodt for use without radiological restrictions (ORNL 1981). Plant 7 was decontaminated to meet criteria and was released for use with no radiological restrictions in 1962 (DOE 1993). When MED/AEC operations at Mallinckrodt were completed in 1962, buildings owned by the government had either been demolished or transferred to Mallinckrodt. Since then, a number of buildings that existed in 1962 have been razed, and a number of new buildings have been constructed at Plants 6 and 10; some of these buildings are being used for the commercial production of chemicals by Covidien. Additionally, since 1962, much of the superstructure used for MED/AEC operations has been demolished and some underground utilities have been abandoned in place.

Non-MED/AEC radiological work was also completed by Mallinckrodt. C-T ores were processed under a separate NRC Source-Material License. While a majority of the work was performed at Plant 5, C-T activities also took place at Plant 1, Plant 3, Plant 6, Plant 7, and Plant 8 areas. C-T activities began in 1961 and continued through 1985, and again briefly in 1987. Some C-T waste was buried at Plant 6 beneath Building 101 (Figure 1-3).

### 1.2.3 Previous Site Characterization Studies

Several characterization studies of various media (i.e., soil, sediment, ground water, sewers, and buildings) have been conducted at the SLDS since 1977. Table 1-2 provides an overview of some of the characterization studies that were conducted and the types of sampling activities that were completed. The RI WP provides a detailed discussion of the major characterization studies conducted at the SLDS and an overview of characterization studies on a property-by-property basis (USACE 2009a). The existing characterization data and the results of the 1993 BRA were used to predict the extent of contamination in the ISOU and to streamline the data needs for this RI. The 1998 ROD defined the nature of contamination at the SLDS based on the results of the previous RI and characterization studies at the SLDS.

Data collected from pre-design investigations (PDIs) and final status surveys (FSSs) conducted as part of the remediation activities for accessible soil also yielded characterization data useful in determining potentially contaminated inaccessible soil areas or structures. Ongoing work at the accessible portions of the SLDS under the authority of the 1998 ROD continues to yield new data that is relevant to the ISOU. Ongoing investigations have been used to supplement and/or modify RI sampling, as appropriate. This report captures the data collected up to June 15, 2011, and considers all areas in the typical inaccessible profile to be part of the ISOU unless specifically excluded or addressed under the 1998 ROD. Some completed PDI and final status survey evaluation (FSSE) reports are identified in Table 1-2.

## Table 1-2. Historic Characterization Studies Supporting the Inaccessible Soil Operable Unit

| Location | Characterization Study | Reference Document |
|---|---|---|
| Plants 1, 2, 6, 6E, 7, and 10 | <u>Oak Ridge National Laboratory, July through September 1977</u><br>**Radiological survey and sampling at locations of MED/AEC processing activities**<br>• Performed direct alpha and beta-gamma measurements and removable alpha and beta measurements on 21 buildings, including indoor walls, floors, ledges, drains, outdoor pads, loading docks, buildings, and roofs<br>• Performed surface and subsurface soil sampling in areas of suspected contamination (e.g., below some buildings and parking lots and near RR spurs)<br>• Collected ground-water samples from 31 auger holes<br>• Collected sediment from indoor and outdoor building drains<br>• Performed surface-water sampling along the Mississippi River at four locations where runoff from the site drains into the river | *Radiological Survey of Mallinckrodt Chemical Works* (ORNL 1981) |
| Plants 1, 2, 6, 7, and 10; St. Louis City Property (DT-2); and Background Location | • RI for the SLS<br>• Site characterization Phase 1 and Phase 2<br>• Performed walkover gamma scan of soil in specific areas with suspected contamination<br>• Performed biased and systematic sampling of surface and subsurface soil for radiological and chemical analyses of metals, VOCs, Resource Conservation and Recovery Act (RCRA) characteristics, and base/neutral and acid extractables<br>• Installed eight ground-water monitoring wells and conduct quarterly ground-water sampling<br>• Conducted a radiological survey and collected sediment samples from drains, sumps, and sewers<br>• Performed direct alpha and beta-gamma measurements and removable alpha and beta measurements were performed on interior surfaces (e.g., floors, walls, ceilings, and roofs) of 20 buildings associated with processing operations<br>• Collected biased soil samples of surfaces in building interiors for radiological analysis<br>• Conducted additional surface and subsurface soil sampling for radiological and chemical analyses for metals and RCRA hazardous waste characteristics<br>• Installed one additional ground-water monitoring well<br>• Performed direct alpha and beta-gamma measurements and removable alpha and beta measurements were performed on additional surfaces of former processing buildings | *Remedial Investigation Report for the St. Louis Site, St. Louis, Missouri* (BNI 1994)<br>*Remedial Investigation Addendum Report for the St. Louis Site, St. Louis, Missouri*, (DOE 1995)<br>*Radiological, Chemical, and Hydrogeological Characterization Report for the St. Louis Downtown Site* (BNI 1990a) |

**Table 1-2. Historic Characterization Studies Supporting the Inaccessible Soil Operable Unit (Continued)**

| Location | Characterization Study | Reference Document |
|---|---|---|
| Plant Areas, DT-1, DT-3, DT-8, DT-9, DT-10, and DT-12 | • RI Addendum: 1992 – 1993<br>• Performed supplemental soil sampling for radiological analysis to refine the boundaries of soil contamination at the plant areas as well as six VPs<br>• Collected 10 background soil samples at Hyde Park to establish background for chemicals<br>• Sampled sediment from manholes, sumps, and drain lines<br>• Collected radon measurements in 19 buildings<br>• Collected sediment samples from the Mississippi River<br>• Installed an additional ground-water monitoring well<br>• Performed beta-gamma survey the interior of Building 101 | *Remedial Investigation Report for the St. Louis Site, St. Louis, Missouri* (BNI 1994)<br>*Remedial Investigation Addendum Report for the St. Louis Site, St. Louis, Missouri* (DOE 1995)<br>*Preliminary Radiological Survey Report for the Chicago, Burlington, and Quincy Railroad Property in St. Louis, Missouri* (BNI 1989e)<br>*Report on the Limited Radiological Survey of the PVO Foods, Inc. Property in St. Louis, Missouri* (BNI 1989f)<br>*Preliminary Radiological Survey Report for the Norfolk and Western Railroad Property in St. Louis, Missouri* (BNI 1989d)<br>*Preliminary Radiological Survey Report for the St. Louis Terminal Railroad Property in St. Louis, Missouri* (BNI 1989c)<br>*Report on the Limited Radiological Survey of the Thomas and Proetz Lumber Company Property in St. Louis, Missouri* (BNI 1989b)<br>*Report on the Limited Radiological Survey of the McKinley Iron Company Property in St. Louis, Missouri* (BNI 1989a) |
| City-owned Property Located North and South of the SLDS | <u>Background Soil: 1998</u><br>• Sampled boreholes to provide background soil concentrations of chemicals and radionuclides | *Background Soils Characterization Report for the St. Louis Downtown Site* (USACE 1999a) |
| Plant Areas and VPs | <u>PDI and FSSE: 1998 to 2010</u><br>• Characterized accessible soil<br>• Characterized properties included in the boundary enlargement of the 2005 Memorandum for Record (USACE 2005a)<br>• Conducted GWSs to identify areas of elevated radiological contamination above background<br>• Conducted systematic, random, and biased soil sampling<br>• Conducted verification sampling at remediation areas<br>• Identified inaccessible soil areas of detected contamination | <u>Various titles including:</u><br>*Pre-Design Investigation Data Summary Report Gunther Salt North Vicinity Property (DT-4), FUSRAP St. Louis Downtown Site, St. Louis, Missouri* (IT 2001a)<br>*Post-Remedial Action Report for the Accessible Soils within the St. Louis Downtown Site Plant 2 Property* (USACE 2002a)<br>*Post-Remedial Action Report for the Accessible Soils within the St. Louis Downtown Site, Heintz Steel and Manufacturing Vicinity Property (DT-6), and Midwest Waste Vicinity Property (DT-7), St. Louis, Missouri* (USACE 2005b)<br>*Final Status Survey Evaluation for the Accessible Soils within the St. Louis Downtown Site Vicinity Properties West of Broadway, Mallinckrodt Plants 3, 8, 9, 11 and Parking Lots* (USACE 2006)<br>*Pre-Design Investigation and Final Status Survey Evaluation for the Accessible Soils within the St. Louis Downtown Site Vicinity Properties DT-35 and DT-36* (USACE 2009b)<br>*Post-Remedial Action Report and Final Status Survey Evaluation for the Accessible Soils within the St. Louis Downtown Site Vicinity Property Thomas and Proetz Lumber Company (DT-10)* (USACE 2010a) |

GWS = Gamma walkover survey.
VOC = Volatile organic compound.

## 1.3 REPORT ORGANIZATION

This RI was conducted in accordance with USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA 1988a). Data collected as part of this RI are detailed in this report and provide a basis for defining the nature and extent of contamination. The RI data were used to perform a BRA to evaluate human health impacts from inaccessible soil, sediment within sewers, soil adjacent to sewers, and buildings and other permanent structures in the ISOU. The report is organized as follows:

***Section 1.0: Introduction*** describes the purpose of this report as well the site background and previous characterization studies of the SLDS.

***Section 2.0: Study Area Investigation*** includes a summary of the determination of the Potential Contaminants of Concern (PCOCs), the completed sampling activities, descriptions of field methods used, and an evaluation of data usability.

***Section 3.0: Physical Characteristics of Study Area*** describes the physical characteristics of the site, including geologic and hydrogeologic conditions, surface-water hydrology, ecological resources, demographics, and land use.

***Section 4.0: Nature and Extent of Contamination*** describes the screening levels, contaminant source areas, PCOCs, and the nature and extent of contamination in inaccessible soil areas, sediment within sewers, the soil adjacent to the sewers, and soil on buildings and other permanent structures.

***Section 5.0: Contaminant Fate and Transport*** introduces the conceptual site model (CSM) as it pertains to source release mechanisms and environmental transport pathways under current ISOU conditions. This section also describes PCOC-specific contaminant mobility and persistence characteristics.

***Section 6.0: Baseline Risk Assessment*** summarizes the exposure assessments presented in the human health risk assessment (HHRA) including exposure assessment, dose-response assessment, and risk evaluation. The detailed BRA is presented in Appendix K.

***Section 7.0: Summary and Conclusions*** includes a summary of site conditions for the ISOU including identification of contaminants of potential concern (COPCs) and the estimation of the nature and extent of the COPCs. This section also describes data limitations and defines potential remedial action objectives (RAOs) for the ISOU.

***Section 8.0: References***

# 2.0 STUDY AREA INVESTIGATION

This section summarizes the RI field investigation activities conducted to fill data needs identified in the RI WP. The RI methodology presented in the RI WP was developed using USEPA's seven step data quality objective (DQO) process as outlined in the *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA 2006) to ensure defensible data was obtained to evaluate the risk associated with the ISOU media.

## 2.1 POTENTIAL CONTAMINANTS OF CONCERN

The purpose of the RI is to define the nature and extent of MED/AEC soil contamination present in the ISOU media. Due to the history and diverse nature of the industries located at and surrounding the SLDS, many of the organic and non-radioactive inorganic chemicals detected during the previous characterization activities cannot be attributed to one source, industry, or event. A review of the past uranium processing activities at the SLDS indicated that chemical contamination consists primarily of elemental metals (USACE 1998b). The constituents that were evaluated in the 1993 BRA are those that DOE is responsible for addressing during the remedial process. The 1993 BRA states: "*Such responsibilities are limited to all radioactive and nonradioactive contamination at the SLDS, [St. Louis Airport Site] SLAPS, and Latty Avenue Properties and their related vicinity properties that is associated with the original processes conducted at the SLDS under the MED/AEC programs. In addition, DOE is responsible for any other chemical (nonradioactive) contamination, not related to the process, that is commingled with identified radioactive wastes.*"

The 1993 BRA used the concentrations and distribution of potential radiological and chemical contaminants identified as being within the scope of MED/AEC to characterize the risks associated with the SLS, including the SLDS. The 1993 BRA concluded that the primary radioactive contaminants in soil and sediment at the SLDS were Ra-226, Th-232, Th-230, U-238, and U-235 and its decay products (including Ac-227 and Pa-231). The 1993 BRA estimated that CRs to receptors from exposures to radioactive contaminants at the SLDS exceeded USEPA's target CR range for most current industrial land use and all future land use scenarios evaluated (DOE 1993).

Chemical constituents in soil, sediment, and ground water evaluated for carcinogenic and non-carcinogenic risk in the 1993 BRA (DOE 1993) included volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, and inorganic anions. Risk characterization tables in the 1993 BRA show that carcinogenic risks and/or non-carcinogenic hazard quotients (HQs) exceeded USEPA's *de minimus* criteria of 1E-06 and 1.0, respectively, for each of the following contaminants: antimony, arsenic, beryllium, nickel, thallium, and polycyclic aromatic hydrocarbons (PAHs). During the 1998 FS, further evaluation of COCs for the SLDS was conducted. The 1998 FS evaluation concluded that, although thallium and PAHs were previously identified as PCOCs, these substances are not attributable to MED/AEC operations (USACE 1998b). The list of metals for soil was further refined to include only arsenic, cadmium, and uranium metal. Copper and nickel were eliminated during additional evaluations due to the low concentrations, distribution, and toxicity (USACE 1998a).

The list of PCOCs for the ISOU was defined as those radiological and chemical contaminants identified as being attributable to MED/AEC contamination, as shown in Table 2-1.

**Table 2-1. Potential Contaminants of Concern for the Inaccessible Soil Operable Unit**

| Chemical Constituents | Radiological Constituents |
|---|---|
| Arsenic[a,b] | Ra-226 |
| Cadmium[a,b] | Ra-228 |
| Cobalt[b] | Th-228 |
| Copper[b] | Th-230 |
| Lead[b] | Th-232 |
| Manganese[b] | U-235 |
| Molybdenum[b] | U-238 |
| Nickel[b] | Ac-227 |
| Selenium[b] | Pa-231 |
| Thorium[b] | |
| Uranium[a,b] | |
| Vanadium[b] | |
| Zinc[b] | |

[a] Applicable to soil in the uranium-ore processing area: Plants 2, 6, and 7, DT-10, and portions of DT-9, DT-12, Hall Street, Mallinckrodt Street, and Destrehan Street (USACE 1998a).

[b] Metals were identified as PCOCs in sewer sediment and soil adjacent to sewers for sampling and laboratory analysis. Because sewer sediment and soil adjacent to sewers has not been characterized for metals, all metals associated with pitchblende and domestic ores used in the former MED/AEC uranium-ore processing operations (DOE 1993) were identified as PCOCs in sewer sediment and soil adjacent to sewers. The list of PCOCs for sewer sediment and soil adjacent to sewers includes arsenic and cadmium, which were identified as soil PCOCs (see footnote "a" above).

The inaccessible soil PCOCs selected as the starting point for the ISOU RI were those radionuclides and metals identified as COCs in the 1998 ROD [(i.e., the primary radioactive contaminants in soil and sediment at the SLDS including Ra-226, Ra-228, Th-228, Th-230, Th-232, U-238, U-235 and its decay products (including Ac-227 and Pa-231), and the metal contaminants including arsenic, cadmium, and uranium metal)] (USACE 1998a, DOE 1993). The same radiological PCOCs are being evaluated in sediment in sewers used for MED/AEC operations, as well as the soil adjacent to those sewers. Additionally, sewer sediment and soil adjacent to sewers used for MED/AEC operations were not analyzed for metals during past investigations; therefore, all metals associated with formerly used pitchblende and domestic ores were identified as PCOCs for sampling and analysis of sediment and soil adjacent to sewers (See Table 2-1). These metals include arsenic, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, vanadium, and zinc.

The derivation of chemical contaminants potentially attributable to MED/AEC operations indicated that chemical contamination consists primarily of elemental metal compounds resulting from uranium-ore processing operations (USACE 1998b). The plant properties within the boundary where the uranium-ore processing was conducted by MED/AEC are Plant 2, Plant 6, and Plants 7N and 7S (Figure 1-2). Some VPs that are adjacent to these plant areas were also included in the MED/AEC uranium-ore processing area due to potential migration of contaminants. These VPs include the Thomas and Proetz Lumber Company (DT-10), portions of the Terminal RR (DT-9) between Plants 2 and 6, portions of the BSNF RR (DT-12) adjacent to Plants 6 and 7, portions of Destrehan Street adjacent to Plants 2, 6, and Plants 7N and 7S, Hall Street between Plants 2 and 6, and portions of Mallinckrodt Street adjacent to Plant 2 (Figure 1-2). All other plant properties and VPs are outside of the uranium-ore processing area and, therefore, only have radiological PCOCs.

## 2.2 SUMMARY OF REMEDIAL INVESTIGATION ACTIVITIES

RI sampling began in June 2009 and ended in August 2010 with the majority of work being completed between October 2009 and May 2010. The data collected were used to evaluate the nature and extent of MED/AEC contamination in ISOU media of concern (Section 4.0), to identify contaminant ISOU-specific fate and transport mechanisms (Section 5.0), and to determine COPCs for the BRA (Section 6.0 and Appendix K).

The specific survey and sampling activities conducted and methods used during the RI are as listed below and discussed in this section:

- inaccessible soil investigations beneath buildings, structures, RRs, and roads (Section 2.2.1);
- building and structural radiological surveys (Section 2.2.2);
- investigations of sewer sediment and soil adjacent to sewers (Section 2.2.3);
- quality assurance (QA)/quality control (QC) sampling and analysis (Section 2.2.4);
- equipment decontamination (Section 2.2.5);
- management of investigation-derived waste (IDW) (Section 2.2.6); and
- data validation and quality assessment (Section 2.2.7).

### 2.2.1 Inaccessible Soil Investigations

Soil sampling was conducted in the inaccessible soil areas to determine the extent of contamination of the PCOCs. Field soil sampling activities were conducted in accordance with the methods and procedures specified in the RI WP (USACE 2009a) from June 2009 to August 2010. Table 2-2 summarizes the number and type of samples collected for evaluation of inaccessible soil by plant area or VP. Soil investigations consisted of surface (typically within the first 0.5 ft below ground cover) and subsurface soil sampling for radiological and chemical constituents. All soil samples were analyzed for radionuclides (Ac-227, Pa-231, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-235, and U-238) and soil samples from some locations inside the uranium-ore processing area were analyzed for metals (arsenic, cadmium, and uranium metal). Soil analytical results are discussed in Section 4.0.

The typical horizontal boundary for inaccessible soil beneath or adjacent to a structure is defined as the footprint of the structure, including the area beneath the structure's foundation and the area surrounding the structure, extending 5 ft outward from the foundation (USACE 1999b) (Figure 2-1). These boundaries were defined based on engineering and safety concerns. The typical horizontal boundary for inaccessible soil beneath or adjacent to a roadway is defined as the roadway and its associated ROW extending 5 ft from the edge of the pavement (USACE 1999b) (Figure 2-2). The typical horizontal boundary for inaccessible soil beneath or adjacent to a RR track is defined as the area that includes the track and the associated RR ROW extending to a distance of 10 ft from the outermost rail of the track (USACE 1999b) (Figure 2-3).

Gamma walkover surveys (GWSs) were conducted to identify elevated gamma radioactivity in soil beneath or associated with buildings, structures, roads, and RRs for potential biased soil sampling locations. GWSs were performed using a Ludlum Model 44-10 2 × 2 sodium-iodide (NaI) detector coupled with a global positioning system (GPS) when possible. GPSs have limited effectiveness inside or around structures due to satellite signal interference. In these situations, the GWS readings were recorded manually on paper survey forms.

GWS coverage was approximately 50 to 100 percent (%) of the footprint of buildings or other permanent structures (e.g., roadway and RR). Typically, 100% coverage of the ground floor was attempted within buildings. However, coverage was sometimes affected by interferences (i.e., equipment, piping, materials, walls, etc.). Granite, brick, ceramics, and some concrete exhibit naturally occurring elevated radioactivity; therefore, the nature of the construction materials was considered when interpreting GWS results. The ambient background for each survey area was determined at the start of the survey, and locations exhibiting activity 1.5 times or higher above background were further investigated and, if appropriate, sampled.

## Table 2-2. Remedial Investigation Characterization Activities by Sample Media and Number of Sampling Locations

| Property Area | Number of Inaccessible Soil Sampling Locations | | | Number of Building Surfaces Surveyed | | | Number of Sewer Sampling Locations | |
|---|---|---|---|---|---|---|---|---|
| | Systematic or Random Sampling | Biased Soil Sampling | GWS at Building, Roadway, or RR | Interior | Exterior | Rooftop | Sediment Sampling | Adjacent Soil Sampling |
| Plant 1 | 16 | 30 | 12 | 17 | 20 | 15 | 11 | 17 |
| Plant 2 | 13 | 14 | 6 | 6 | 6 | 2 | 10 | 5 |
| Plant 6 | 0 | 7 | 0 | 1 | 1 | 0 | 3 | 2[c] |
| Plant 7N and 7S | 0 | 1 | 0 | No buildings[a] | | | 1 | 1[c] |
| Plant 10 | Out of scope; previously remediated | | | | | | Non-impacted[b] | |
| Mallinckrodt West Properties (Plants 3, 8, 9, and 11, and parking lots) | 0 | 2 | 0 | 0 | 7 | 4 | Non-impacted[b] | |
| Mallinckrodt Security Gate 49 Area | 0 | 2 | 1 | Non-impacted[b] | | | No sewers present | |
| St. Louis City Property (DT-2) | 10 | 7 | 0 | No buildings | | | 0 | 0[c] |
| Gunther Salt (DT-4) North | 15 | 23 | 4 | 3 | 5 | 3 | No sewers present | |
| Gunther Salt (DT-4) South | Non-impacted[b] | | | Non-impacted[b] | | | Non-impacted[b] | |
| Heintz Steel (DT-6) | 14 | 10 | 2 | 2 | 2 | 1 | No sewers present | |
| PSC Metals, Inc. (DT-8) | 41 | 8 | 9 | 5 | 6 | 1 | 0 | 3 |
| Thomas and Proetz Lumber Company (DT-10) | 8 | 4 | 2 | 6 | 7 | 2 | No sewers present | |
| Illinois Department of Transportation and Missouri Department of Transportation, (McKinley Bridge) (DT-11) | Included in roadways | | | No buildings Structures Non-impacted[b] | | | 1 | 0 |
| MSD Lift Station (DT-15) | 4 | 0 | 1 | Non-impacted | | | Location identified with DT-8 | |
| Midtown Garage (DT-29) | Non-impacted[b] | | | Non-impacted[b] | | | Non-impacted[b] | |
| Hjersted (DT-34) | Non-impacted[b] | | | Non-impacted[b] | | | Non-impacted[b] | |
| South of Angelrodt Property Group | Non-impacted[b] | | | 0 | 1 | 1 | Non-impacted[b] | |
| West of Broadway Property Group | Non-impacted[b] | | | 0 | 5 | 5 | Non-impacted[b] | |
| RR Properties (DT-3, Norfolk-Southern RR) | 70 | 10 | 1 | No buildings; sewers addressed with property areas | | | | |
| Terminal RR (DT-9) | 127 | 17 | 3 | No buildings; sewers addressed with property areas | | | | |
| Terminal RR Soil Spoils Area | 7 | 0 | 1 | No buildings | | | Non-impacted[b] | |
| BNSF RR (DT-12) | 165 | 7 | 1 | No buildings; sewers addressed with property areas | | | | |
| Roadways | 83 | 45 | 8 | No buildings; sewers addressed with property areas | | | | |
| Background Locations (sewers) | NA | | | NA | | | 11 | 0 |
| **Total Sample Locations** | **573** | **187** | **51** | **40** | **60** | **34** | **37** | **28** |

[a] The Hazardous Waste Storage Area at Plant 7N was dismantled in 2010.
[b] As described in the RI WP, the specific media (inaccessible soil, sewers, or buildings) at the property were identified as non-impacted; therefore, no RI sampling was conducted.
[c] Excavation sidewall samples adjacent to sewers were collected for this area during remediation activities conducted under the 1998 ROD.

GWSs have limitations due to gamma ray attenuation in areas covered by concrete floor slabs, roadway materials, and gravel. The effectiveness of the GWSs to detect gamma activity under consolidated material depends on the type of consolidated material, the thickness of the material, the radionuclides present, and radionuclide concentrations. Despite these limitations, GWSs are still useful in detecting elevated gamma activity underlying concrete, roadway materials, and gravel.

Soil investigations for radiological assessment were conducted at random, biased, and systematic soil sampling locations. Biased samples were collected at specific areas determined to have a greater likelihood of exceeding the screening level or at areas adjacent to remediated soil areas. Biased samples were also collected at locations where gamma survey measurements or scans were shown to be elevated above background. The soil sampling locations for metal PCOCs (arsenic, cadmium, and uranium metal) were selected from the biased radiological soil sampling locations.

Systematic samples for radiological PCOCs were collected at potentially contaminated inaccessible soil areas using uniform grid spacing. Random sampling for radiological PCOCs was conducted at inaccessible soil areas unlikely to be contaminated to provide reasonable assurance that an area has been sufficiently characterized. Systematic or random sampling for metal PCOCs was not completed because it was expected that areas slated for biased sampling would best characterize any metal contaminants as metals have predominantly been found commingled with radiological PCOCs in the accessible portions of SLDS.

Northing and easting coordinates for the sampling locations were determined using geographic information system (GIS) software and then located in the field using hand-held GPS units when possible. Sample locations inside structures were located by measuring from features (e.g., corners, doorways, etc.). Proposed sample locations were modified, if necessary, based on field conditions that would prevent effective sampling in the proposed locations (e.g., areas with access constraints).

Utility clearance was necessary prior to soil sampling. Prior to initiating soil sampling, available utility maps and historical data were reviewed to help identify utility lines. In the field, the proposed sampling locations were inspected for potential utility impacts. Determination of utility locations in public utility easements was performed through the Missouri "One-Call" system. The locations of overhead and underground utilities were identified, and the locations of the underground utilities were marked on the ground surface. If necessary, the proposed RI WP sample locations were moved a minimal distance to avoid utilities. Once the soil boring locations were determined to be clear of utilities, sampling activities began. In addition, modifications to the proposed sampling locations were necessary when auger refusal occurred prior to reaching the proposed sampling depth. Sampling locations where auger refusal occurred were relocated a minimal distance to ensure that relocation did not impact the intended sampling purpose.

Soil samples were primarily collected utilizing a drill rig with hollow stem augers and a split-spoon soil sampler. In areas that the drill rig could not access (e.g., inside buildings, areas with low overhead clearance, etc.), an electric coring machine was utilized to remove cover material (e.g., concrete, asphalt, etc.) and hand augers were used to collect soil samples. Surface soil sampling was initiated in the uppermost soil layer below any gravel material located beneath consolidated material (i.e., asphalt or concrete). Sampling began by removing a soil column of approximately 1.5 to 2.0 ft below original grade at the sampling location, with two samples collected from this initial soil column. The first sample (i.e., surface soil sample) was taken within the first 0.5 ft of the uppermost soil layer below any consolidated material and associated gravel. The second sample (i.e., subsurface soil sample) was collected from a 0.5 ft interval of the remaining column at the depth that exhibited the greatest radioactivity determined by using a NaI gamma radiation detector or instrument of equal or greater sensitivity. If the soil column exhibited a relatively uniform count rate, the subsurface sample was collected from the deepest 0.5 ft interval of the column. Subsurface sampling continued by removing subsequent soil columns of approximately 2 ft in length until a total minimum depth of 6 ft below original grade was obtained and radioactivity readings were at or near background. A subsurface soil sample was collected from the 0.5 ft interval that exhibited the greatest radioactivity within each 2-ft soil column as determined by using a NaI gamma radiation detector or instrument of equal or greater sensitivity. As noted above for the initial soil column, any subsequent subsurface sample was collected from the deepest 0.5 ft interval of a soil column if the soil column exhibited a relatively uniform gamma radiation count rate. Greater depths were sampled for specific VPs or plant areas as defined in the RI WP or if elevated readings were obtained at the deepest planned sampling depth.

Samples for metals analysis were collected from the same 0.5 ft interval of soil that a radiological sample was collected. Samples were submitted for arsenic, cadmium, and uranium metal analyses. All borings were logged and described by a geologist, geotechnical engineer, or soil scientist. Copies of the soil boring logs for each sampling location are provided in Appendix A.

Industry-standard surveying equipment then was used to measure the as-built coordinates and the corresponding ground surface elevations for each sampling location.

The base reference for surveying coordinates for each sample location was a local, USACE-established, SLDS benchmark. The coordinate and elevation data for the SLDS benchmark and each sample location are referenced to the Missouri State Plane Coordinate System, the North American Datum of 1983, and the North American Vertical Datum of 1988.

### 2.2.2 Buildings and Structures Investigations

In accordance with the RI WP (USACE 2009a), building and structure surfaces (i.e., interior, exterior, and roof) were designated for a scoping survey based on a preliminary assessment that included evaluating previous data collected on the structure, the construction date, use of the structure, the proximity of the structure to MED/AEC processing operations, and the proximity to remediated accessible soil areas. Radiological surveys included scanning for total alpha and beta surface activity and fixed-point measurements for total alpha and beta surface activity using portable radiological survey equipment. Building surveys began in September 2009 and were completed in August 2010.

Table 2-2 summarizes the number of buildings and surfaces surveyed by plant area or VP. Radiological surveys included scanning for total alpha and beta surface activity and fixed-point measurements for total alpha and beta surface activity using portable radiological survey equipment. Results of the radiological investigation of buildings/structures are discussed in Section 4.6.

Building and structure surfaces that were surveyed included, but were not limited to, roofs, exposed exterior and interior surfaces, air vents, vertical and horizontal piping, and piping supports. The scoping surveys were biased, focusing on areas that are prone to accumulate contamination such as horizontal surfaces, depressions, cracked surfaces, rusted or unpainted surfaces, intake and exhaust vents, etc. While in the field, professional judgment also was used to select biased survey locations. The surfaces scanned were defined by the dimensions of each individual building or structure. Generally, 10 to 20% of each building or structure surface area was scanned. The scoping surveys were conducted in accordance with the *Final Status Survey Plan for Structures and Other Consolidated Material Left in Place at the St. Louis Site* [hereafter referred to as the Final Status Survey Plan (FSSP) for Structures] (USACE 2003).

A Ludlum Model 2360 coupled with a Ludlum 43-89 (zinc sulfide plastic scintillator) or equivalent was used to perform the alpha and beta scans. Prior to performing field measurements, the detection sensitivity of the equipment was calculated to ensure that levels were below the ISOU screening level (Section 4.1). Methods for evaluating this detection sensitivity are provided in the FSSP for Structures (USACE 2003). A minimum of 10 fixed data points were taken on structures identified as impacted by MED/AEC related contaminants. The scan speed with these detectors was approximately 1 to 2 inches (in) per second. Distance from the detector probe to the scanned surface was approximately 0.25 in. Instrument response was monitored continuously during scanning through use of the audible instrument signal.

Scoping surveys were conducted from the ground level to the roof line to get representative data on exterior building surfaces. A manlift, capable of reaching 60 ft in height, was utilized for exterior building and roof surveys. Reasonable efforts were made to scan locations where safety considerations or other restrictions prevented access. These areas included those obstructed by overhead piping or utilities and those areas/surfaces (i.e., roofs) that would not safely support access. These areas were minimal and did not jeopardize the objective of the scoping survey. Specific areas that obstructed the scoping survey are discussed in Section 4.6.

Total alpha and beta surface activity (fixed-point) measurements were obtained from areas exhibiting elevated count rates. Fixed-point gross alpha and beta activity measurements were made with a 1-minute static count. The surface activity measurements for both alpha and beta were recorded in counts per minute (cpm), which, along with the appropriate instrument geometry, instrument background, instrument efficiency, and surface efficiency was used to convert the data to disintegrations per minute per 100 square centimeters (dpm/100 cm$^2$), in accordance with the FSSP for Structures (USACE 2003), for comparison to the screening levels. The following equation was used to convert the data recorded in cpm to dpm/100 cm$^2$.

$$Result\left(\frac{dpm}{100\ cm^2}\right) = \frac{R_g - R_b}{(\varepsilon_i)(\varepsilon_s)(Probe\ \ Area/100)}$$

Where:
$R_g$ is the static data point gross count rate (cpm)
$R_b$ is the field background count rate (cpm)
$\varepsilon_i$ is the instrument efficiency (cpm/dpm)
$\varepsilon_s$ is the surface efficiency
*Probe Area* is the open area of the detector face (cm$^2$)

For the purpose of the surveys conducted during this RI, any structure exhibiting fixed-point measurement(s) that exceeded the gross alpha screening level of 3,900 dpm/100 cm$^2$ was subjected to additional evaluation to determine the extent of contamination.

Building materials such as granite, brick, ceramics, and some concrete exhibit alpha and beta activity above area background levels due to naturally occurring radioactivity. Portions of many of the buildings were constructed with materials that contain naturally occurring radioactive materials. The construction material exhibiting the greatest alpha and beta activity from naturally occurring radioactive material was brown clay/ceramic brick-caps, due to the glaze used on such caps (NCRP 1995, NIST 2000). The average alpha activity detected on clay/ceramic brick-caps from three properties (DT-21, DT-22, and DT-25) west of North Broadway is approximately 1,900 dpm/100 $cm^2$. As a conservative assumption, 50% of this value (i.e., 950 dpm/100 $cm^2$) was attributed to natural occurring radioactivity for the clay/ceramic brick-caps surveyed during the RI. Except for the clay/ceramic brick-caps measurements, the scoping survey results do not take into account the naturally occurring radioactivity of the various building materials.

### 2.2.3 Sewer Investigations

The objectives of sewer sampling were to obtain sufficient and representative data to determine the extent of MED/AEC contamination associated with sewers (i.e., interior sediment and surrounding soil) and to evaluate potential contaminant migration pathways associated with sewers.

Table 2-2 summarizes the number of samples of sewer sediment and of soil adjacent to sewers collected by plant area or VP. These areas include sewers that were used for MED/AEC operations or that were located downstream of areas where MED/AEC operations were conducted, based on available data concerning sewer flow directions. In addition to the sampling locations at the plant areas and VPs, sediment sampling was conducted in manholes located upstream (west) of the Mallinckrodt facility to provide background data for comparison. In general, the samples of sewer sediment and soil adjacent to sewers collected during the RI were analyzed for 12 metal PCOCs and nine radionuclide PCOCs identified in Section 2.1. However, at those sampling locations where insufficient sediment was found to conduct both analyses, only the radionuclide analysis was conducted. RI field tasks for the sewers were initiated in December 2009 and completed in August 2010. The results of the sewer sampling are summarized in Section 4.7.

Field activities were conducted in accordance with the methods and procedures specified in the RI WP (USACE 2009a). However, some field changes and/or additions to the proposed sampling locations originally identified in the RI WP were necessary based on information obtained during the field investigation. Some of the proposed manhole sampling locations were not sampled due to access problems (e.g., manhole cover or grate was covered or sealed closed), the lack of adequate volume of sediment required for analysis, or other site conditions (e.g., the presence of sanitary effluent). In these cases, the closest accessible manhole or surface drain was sampled. The number of background sewer sediment sampling locations also was increased to provide a more statistically robust background dataset.

Other related field tasks, including surveying soil boring locations, decontaminating equipment, and managing IDW, were completed as discussed in Sections 2.2.1, 2.2.5, and 2.2.6, respectively.

**Manhole Sediment Sampling:** Sediment sampling activities for the sewers began in December 2009, and were completed in January 2010. Before sampling activities began, manhole covers and grates were removed to inspect their integrity and to determine if a sufficient volume of sediment was available for laboratory analysis. Photographs were taken outside and inside the manhole to document the condition of the manhole and any visible portions of adjoining sewer lines. When visible, the depths to the flowlines of adjoining pipes were measured. If standing water was present, that depth to water in the sewer was also measured. In lieu of entry into the manhole, sewer sediment samples were collected using a long-handled hoe (i.e., a hoe with a polyvinyl chloride extension attached). Excess sample material was returned to the point of origin from which it was collected. Field measurements, sample descriptions, and other relevant information were recorded on soil boring logs, provided in Appendix A.

**Soil Boring Sampling Adjacent to Sewers:** The soil boring sampling approach for sewers was based on available information concerning the operational history of the sewers and the surrounding areas, available sewer maps, and historical analytical manhole sediment data for the SLDS. The borings were located adjacent to representative sections of sewer pipe as well as adjacent to areas of the pipe where leakage was suspected based on historical maps. Consistent with the RI WP, the soil borings were drilled within a horizontal distance of approximately 2 ft of the sewer lines to get sufficiently close to sample the surrounding soil while also maintaining an adequate distance from the sewer lines to ensure the sewer line was not punctured.

Prior to soil sampling adjacent to the sewers, determination of utility locations was performed the same as it was for soil borings. Drilling activities for the soil borings located adjacent to sewers began in February 2010 and were completed in July 2010.

Some modifications were made to the soil sampling approach outlined in the RI WP based on field conditions that would prevent effective sampling in the proposed locations (e.g., access constraints and the presence of utilities). The RI WP specified that a minimum of two soil samples would be collected from each boring at depth intervals of 0 to 2 ft and 2 to 4 ft beneath the base of the sewer line. Based on site conditions, three, rather than two, soil samples were collected from each boring to compensate for uncertainties concerning the depths of the sewer pipes. The additional soil sample was collected at an estimated depth interval from 2 ft above the base of the pipe to the base of the pipe. When the results of field screening indicated the presence of significant concentrations of radionuclides in the deepest sample, additional samples were collected from the underlying soil to bound the vertical extent of contamination. All borings were logged and described by a geologist, geotechnical engineer, or soil scientist. Copies of the soil boring logs are provided in Appendix A.

### 2.2.4 Quality Assurance/Quality Control Sampling and Analysis

During the RI sampling activities, QA/QC samples were obtained and analyzed in accordance with the RI WP (USACE 2009a). The QA/QC sample results are documented in the Quality Control Summary Report (QCSR) contained in Appendix B.

The QA/QC samples included field duplicate samples and split samples collected and analyzed at a targeted frequency of 5% of the number of prime samples analyzed per environmental medium. Soil and sediment samples collected for radiological analyses were submitted to the USACE FUSRAP laboratory located in St. Louis, Missouri. Prime radiological samples analyzed by the USACE FUSRAP laboratory were split with TestAmerica in St. Louis, Missouri. Soil and sediment samples submitted for chemical analyses were sent to TestAmerica in St. Louis, Missouri. Prime chemical samples analyzed by TestAmerica were split with the USACE QA laboratory located in Vicksburg, Mississippi. Laboratory analyses were conducted in accordance with the *Quality Assurance Project Plan for the St. Louis Airport and Downtown Sites, St. Louis, Missouri* (QAPP) (USACE 1998c).

Matrix spike/matrix spike duplicate samples were not collected in field; however, per the laboratory method QA/QC protocol, matrix spike and matrix spike duplicates were selected and analyzed by the laboratory from aliquots of the prime samples.

### 2.2.5 Equipment Decontamination

General decontamination procedures are included in Science Applications International Corporation (SAIC) Field Technical Procedure (FTP) 400 (SAIC 2008). Based on the type of sampling performed, either chemical or radiological, applicable sections of FTP 400 were followed. Sampling equipment used for chemical sampling was washed with phosphate-free detergent and tap water to remove visible contamination. The equipment was then rinsed with tap water, then alcohol, followed by a de-ionized water rinse. Equipment was air dried and wrapped in aluminum foil until additional sampling occurred.

Equipment used for radiological sampling was washed with phosphate-free detergent and water to remove visible soil from equipment. The equipment was then rinsed with tap water and allowed to air dry. Upon completion of decontamination, cquipment was surveyed to ensure there was no residual removable radioactivity from previous sampling.

Small or reusable sampling equipment and any other tools used for intrusive work were decontaminated between sampling locations. Decontamination requirements between samples are referenced in the *Sampling and Analysis Guide for the St. Louis Site, St. Louis, Missouri* [hereafter referred to as the Sampling and Analysis Guide (SAG)] (USACE 2000). Following decontamination, all equipment was surveyed prior to release for unrestricted use. Equipment leaving the site for unrestricted use had contamination levels below the levels listed in Section 8.19.2, "Surface Radioactivity Limits" of the SAG. Contamination survey results were documented in accordance with SAIC Health Physics Procedure HP-11, *Radiological Monitoring* (SAIC 2002).

Larger pieces of equipment, such as drill rigs, were decontaminated with pressurized hot water/steam as necessary. Steps were taken to assure that contamination did not spread to previously uncontaminated areas during the transport of sampling and other equipment. Any equipment deemed to be heavily contaminated was decontaminated in the immediate area of the sample collection or was wrapped in plastic prior to transit to a decontamination area.

### 2.2.6 Management of Investigation-Derived Waste

IDW included surplus soil from subsurface investigations, decontamination fluids, disposable sampling equipment, and personal protective equipment. During the RI sampling, efforts were made to minimize the volume of waste derived from sampling and decontamination procedures and to dispose of IDW in bulk, along with other wastes that may be generated during accessible soil remedial actions. As specified in the SAG (USACE 2000), all waste generated during field activities was drummed at the site for disposal by USACE. IDW generated during RI activities was taken to a USACE-approved location for staging and/or treatment prior to disposition. IDW was managed, stored, and disposed in accordance with MDNR, USEPA, and U.S. Department of Transportation regulations and requirements of the receiving facility and state (USACE 2000). All waste materials were shipped by rail in accordance with the requirements of 49 *CFR* 174, *Carriage by Rail.*

### 2.2.7 Data Validation and Quality Assessment

Radiological data generated by the USACE FUSRAP laboratory and chemical data generated by TestAmerica in St. Louis, Missouri, were validated at a rate of 5% in accordance with the SAG and the RI WP. Data verification was performed on the remainder of all data from each laboratory that was not validated. Split sample data generated by USACE's QA laboratory were verified before inclusion in the QCSR (Appendix B). Validations and verifications were performed electronically using the FUSRAP St. Louis Data and Environmental Information Management System, in which analytical qualifiers denoting data usability were applied based on comparisons to acceptance criteria established for checklist items presented in the QAPP. Reason codes also were generated with each analytical qualifier.

Data validation reports were written for the validated radiological data from the USACE FUSRAP laboratory and data validation checklists were completed for the validated chemical data. Additionally, data validation checklists or verification summaries for each sample delivery group have been retained with the respective laboratory data. The validation/verification checklists, data qualifiers and reason codes, radiological data validation reports, and QCSR, all provide adequate documentation of the evaluations performed for determining quality and usability of the FUSRAP data for meeting project DQOs. Appendix B of this report presents the QCSR and radiological data validation reports.

As discussed in the Data Quality Assessment Summary of the QCSR, all validated/verified data were determined to be usable, with data qualifications and reason codes being applied due to minor issues. Minor data issues resulted in the qualification of some detect and non-detect results as being estimated with appropriate USEPA qualification flags.

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# 3.0 PHYSICAL CHARACTERISTICS OF STUDY AREA

## 3.1 LAND USE AND DEMOGRAPHY

The SLDS is located in the city of St. Louis, Missouri, which is bordered by the Mississippi River on the east and by St. Louis County on the north, south, and west (Figure 1-1).

Land use within a 1-mile (mi) radius of the SLDS includes a mixture of commercial, industrial, and residential uses. The largest property found within the SLDS is the 45-acre former Mallinckrodt property that is currently owned by Covidien. The Mallinckrodt property currently includes a chemical manufacturing plant, support facilities, and administrative buildings that cover a large portion of the SLDS. The remainder of the complex is covered, mostly with asphalt or concrete pavement. The Mallinckrodt property is enclosed by a maintained and patrolled security fence. The closest resident is located on North Broadway approximately 200 ft southwest of the Mallinckrodt Plant 10 property (USACE 1998a).

The VPs encompass over 165 acres of land surrounding the Mallinckrodt property with similar topography, geology, hydrogeology, and surface-water features.

The SLDS properties are currently zoned industrial, which does not allow new residential land use. The long-term plans by the city of St. Louis for the SLDS area are to retain the industrial uses, encourage the wholesale produce district, and phase out the remaining residential land uses located west of the SLDS.

## 3.2 TOPOGRAPHY, DRAINAGE, AND SURFACE WATER

St. Louis is located in an area of gently rolling uplands that feature low hills and broad, shallow valleys that gradually flatten out to the north and east in Illinois. The hilly terrain is cut by several broad river valleys (up to 10 mi wide) with steep bluffs. The Illinois and Mississippi Rivers converge northwest of St. Louis and are joined downstream by the Missouri River from the west. Both the Mississippi and the Missouri Rivers have cut large valleys with wide floodplains. St. Louis is built on bluffs that rise above the western banks of the Mississippi River, 13 mi downstream of the Missouri River - Mississippi River confluence.

At the SLDS, surface elevations range from approximately 430 ft above mean sea level (amsl) in the southwestern part of the site to 420 ft amsl near the Mississippi River. The SLDS ground surface slopes at an average of 0.4% eastward toward the Mississippi River. An extensive levee system parallel to the Mississippi River has been constructed near the riverbank to protect the city from flooding. The top of the Mississippi River levee is approximately 438 ft amsl and is designed to protect against a 500-year flood event. Surface drainage is directed through ditches and catchment basins into an extensive storm drainage system that discharges to a nearby MSD sewage treatment plant (i.e., the Bissell Plant). The surface water is treated at the plant prior to discharge to the Mississippi River. Much of the SLDS area is covered with concrete or asphalt, which interferes with natural surface-water runoff and ground-water recharge mechanisms (DOE 1993). No permanent surface-water bodies exist within the boundaries of the SLDS.

The Mississippi and Missouri Rivers are the major water supply sources for the St. Louis area. All of the St. Louis area municipal water intakes are located upstream of the SLDS except for the Illinois-American Water Plant, which supplies a small percentage of the water required by the city of East St. Louis, Illinois. The Illinois-American Water Plant intake is located approximately 8 mi downstream of the SLDS on the opposite (east) bank of the Mississippi River.

## 3.3 SITE GEOLOGY AND HYDROGEOLOGY

A generalized stratigraphic column for the SLDS is shown on Figure 3-1. Surficial fill is present over most of the property with an average thickness of 13 ft (BNI 1994). The fill consists of brick, concrete, organic material, and coal slag with minor sand, coal ash, coal cinders, and silt. Underlying the fill, there are two depositional units that are identified based on differences in their geologic properties: an upper unit, consisting of clay and silty clay with interbedded clay, silt, and sandy silt, ranging in thickness from 10 to 17 ft; and a lower unit comprised of sandy silt, silty sand, and gravelly sand deposits ranging in thickness from 0 to 60 ft.

The uppermost bedrock unit at the SLDS is the Mississippian-age Ste. Genevieve Formation, which consists of moderately fractured limestone with some dolomite. The erosional surface of the bedrock dips eastward from a depth of approximately 19 ft below ground surface (bgs) at the western edge of the SLDS to a depth of approximately 80 ft bgs near the Mississippi River.

Ground water at the SLDS is found within the following three hydrostratigraphic units (HUs), in order of increasing depth (Figure 3-1):

- HU-A, which consists of fill and underlying fine-grained deposits (primarily silty clay, clay, and silt);
- HU-B, also referred to as the Mississippi Alluvial Aquifer, which predominantly consists of somewhat coarser-grained deposits (sandy silt, silty sand, sand, and gravelly sand); and
- HU-C, the limestone bedrock.

HU-A overlies the Mississippi Alluvial Aquifer (HU-B) on the east side of the SLDS and overlies bedrock on the western side of the SLDS. HU-A is not an aquifer and is not considered a potential source of drinking water because it has insufficient yield and poor natural water quality.

HU-B thins westward on the bedrock surface until it becomes absent beneath the SLDS, being truncated by the rising bedrock and the overlying HU-A. HU-B is one of the principal aquifers in the St. Louis area. It qualifies as a potential source of drinking water under the *Guidelines for Ground-Water Classification under the EPA Ground-Water Protection Strategy* (USEPA 1988b). However, expected future use of HU-B as a drinking water source at the SLDS is highly unlikely for several reasons: the industrial setting, the site's proximity to the Mississippi and Missouri Rivers (i.e., major water supply sources), and the poor natural water quality of HU-B. Because ground water in HU-B is hydraulically connected to the Mississippi River, ground-water flow direction and gradient are strongly influenced by river stage. The predominant ground-water flow direction is to the east, toward the Mississippi River.

Aquifers in this region also exist in the limestone bedrock (HU-C) underlying the alluvial deposits. HU-C would be an unlikely water supply source because it is deeper and less productive.

There are no known drinking water wells in the vicinity of the SLDS. The City of St. Louis has Ordinance 66777 which explicitly forbids the installation of wells into the subsurface for the purposes of using the ground water as a potable water supply (City of St. Louis 2005). The expected future use of SLDS ground water is not anticipated to change from its current use.

## 3.4 ECOLOGICAL AND CULTURAL RESOURCES

The SLDS is located in the Oak-Hickory-Bluestem Parkland section of the Prairie Parkland Province. Pre-settlement vegetation is characterized by deciduous woodlands intermixed with open prairie. Today, the ecological resources at the SLDS are limited because of the site's location within an urban area of concentrated industrial and commercial developments (DOE 1993). Site vegetation consists of a mixture of prairie species, disturbance-related aggressive species, and species typical to old fields including wild carrot, aster, clover, dandelion, milkweed, ragweed, and various grasses (DOE 1993).

Vertebrate fauna of the St. Louis area consist of species that have adapted to urban encroachment, including mammals (e.g., mice, opossum, eastern cottontail rabbit, gray squirrel, and eastern mole) (DOE 1993). Birds that inhabit the urban environment include the Canada goose, rock dove, mourning dove, American crow, American robin, and Northern cardinal (DOE 1993).

No wetlands occur within the SLDS boundaries, although according to the U.S. Fish and Wildlife's National Wetlands Inventory (USFWS 2008), a portion of the area directly north of the McKinley Bridge and east of the Mississippi River levee is classified as palustrine wetlands, which are commonly found along the Mississippi River. Overall, no potentially important habitats for biota occur either on-site or adjacent to the SLDS (DOE 1993).

Available data indicate that no archaeological sites or historic buildings lie within the SLDS boundaries and no archeological survey has been conducted at the site. Due to the intensive industrial use of the site, it is unlikely that any significant archeological sites exist at the SLDS (USACE 1998b). Two sites listed in the March 1992 edition of the National Register of Historic Places for the state of Missouri exist within 1 mi of the SLDS. The first site is the Bissell Street Water Tower, located northwest of the SLDS, and the second is the Murphy-Blair Historic District, located 0.5 mi southwest from the SLDS. Additionally, an official historic district (Hyde Park) is located west and northwest of the SLDS.

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# 4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents the results of the RI sampling to define the nature and extent of contamination in ISOU media. A detailed overview of each plant or property, including a property description, history of MED/AEC use, summary of previous investigations, and a review of the previously existing characterization data, is provided in the RI WP (USACE 2009a). RI sampling was conducted between June 2009 and August 2010. The data collected as part of this RI were evaluated for the defined PCOCs as discussed in Section 2.1. The results of the RI for inaccessible soil at each property are presented in Section 4.2 through 4.5, the results of building surveys at each property are presented in Section 4.6, and the results of the sewer investigation are presented in Section 4.7. A summary of the nature and extent of contamination is provided in Section 4.8.

## 4.1 DATA EVALUATION PROCESS FOR THE POTENTIAL CONTAMINANTS OF CONCERN

To evaluate the nature and extent of contamination at each plant area or VP, screening levels were established for each PCOC. Screening levels were established for inaccessible surface soil (0 to 0.5 ft bgs), inaccessible subsurface soil (>0.5 ft bgs), sewer sediment and soil adjacent to sewers, and building and structure surfaces. The analytical results from each sampling location and sampling depth were compared to the screening levels.

Screening levels are health-based concentrations for the radiological and metal PCOCs. Radiological screening levels are dose-based and metal screening levels are risk-based. Concentrations below screening levels are unlikely to cause any health risks following exposure, assuming exposures occur in a manner consistent with the exposure assumptions used to derive the screening levels.

The screening levels for the RI were used in a conservative manner because they were applied to individual sampling results and/or locations collected during the RI rather than to upper-bound average concentrations derived for an area per USEPA methodology [e.g., the 95% upper confidence limit (UCL) of the arithmetic mean concentration]. The ISOU screening levels that were used are presented in Table 4-1.

**Table 4-1. Screening Levels and Background Values for Potential Contaminants of Concern Identified for the Inaccessible Soil Operable Unit**

| Media | Depth | PCOC | Screening Level [a] | Soil BV [a,b] | Sediment BV [a,b] |
|---|---|---|---|---|---|
| Inaccessible Soil | 0 – 0.5 ft | Ra-226 | 5 | 2.78 | NA |
| | | Ra-228 | 5 | 0.95 | NA |
| | | Th-230 | 5 | 1.94 | NA |
| | | Th-232 | 5 | 1.09 | NA |
| | | U-238 [c] | 50 | 1.44 | NA |
| | | $SOR_N$ | ≥1.0 | NA | NA |
| | >0.5 ft | Ra-226 | 15 | 2.78 | NA |
| | | Ra-228 | 15 | 0.95 | NA |
| | | Th-230 | 15 | 1.94 | NA |
| | | Th-232 | 15 | 1.09 | NA |
| | | U-238 [c] | 50 | 1.44 | NA |
| | | $SOR_N$ | ≥1.0 | NA | NA |
| | All depths | Arsenic [d] | 60 | 21.76 | NA |
| | All depths | Cadmium [d] | 17 | 3.80 | NA |
| | All depths | Uranium metal [d] | 3,100 | NA | NA |

**Table 4-1. Screening Levels and Background Values for Potential Contaminants of Concern Identified for the Inaccessible Soil Operable Unit (Continued)**

| Media | Depth | PCOC | Screening Level [a] | Soil BV [a,b] | Sediment BV [a,b] |
|---|---|---|---|---|---|
| Sewer | Sediment (0 – 0.5 ft) and Soil adjacent to sewers (> 0.5 ft) | Ra-226 | 15 | 2.78 | 0.044 |
| | | Ra-228 | 15 | 0.95 | 0.356 |
| | | Th-230 | 15 | 1.94 | 1.02 |
| | | Th-232 | 15 | 1.09 | 0.41 |
| | | U-238 [c] | 50 | 1.44 | 0.3 |
| | | $SOR_N$ | ≥1.0 | NA | NA |
| | | Arsenic [e] | 1.6 | 21.76 | 11.8 |
| | | Cadmium [f] | 17 | 3.80 | 6.16 |
| | | Cobalt [e] | 300 | 14.02 | 8.56 |
| | | Copper [e] | 41,000 | 1,660 | 157 |
| | | Lead [e] | 800 | 2,980 | 602 |
| | | Manganese [e] | 23,000 | 975 | 626 |
| | | Molybdenum [e] | 5,100 | 7.8 | 7.16 |
| | | Nickel [e] | 20,000 | 40.49 | 34.0 |
| | | Selenium [e] | 5,100 | 0.96 | 2.94 |
| | | Thorium | [g] | NA | NA |
| | | Uranium metal [e] | 3,100 | NA | 17.9 |
| | | Vanadium [e] | 5,200 | 138 | 19.4 |
| | | Zinc [e] | 310,000 | 2,000 | 659 |
| Structures [h] | Surface | Gross alpha activity | 3,900 dpm/100 $cm^2$ | NA | NA |
| | Surface | Gross beta activity | [i] | NA | NA |

[a] Radiological parameters are reported in picocuries per gram (pCi/g). Metals parameters are reported in milligrams per kilogram (mg/kg).
[b] All site-specific soil background values (BVs) presented for radionuclides and metals were obtained from USACE (1999a). Site-specific sewer sediment BVs for radionuclides and metals were collected during the RI (see Table 4-5 for statistical summary). Soil and sediment BVs for radionuclides are based on mean activity concentrations. Because all upper tolerance limits (UTLs) for metals exceed maximum detections, each soil and sediment BV presented for the metals represents the lesser of the 95% UCL of the arithmetic mean concentration versus the maximum detected background concentration.
[c] U -238 serves as a surrogate for the other uranium isotopes [uranium-234 (U-234) and U-235] and certain decay products (Pa-231 and Ac-227) that are present with U-238.
[d] Metal PCOCs are identified for specific areas designated as being within the uranium-ore processing area of the SLDS. See Section 2.1.
[e] Sediment and soil adjacent to sewers screening level for metal is represented by the USEPA's (2011a) Regional Screening Level (RSL) for industrial land use.
[f] Sediment and soil adjacent to sewers screening level for cadmium is represented by the soil RG derived in the 1998 ROD (USACE 1998a).
[g] A risk-based ISOU screening level for elemental thorium is not available. Radiological isotopes will drive the risk evaluations of thorium.
[h] No metal screening levels are needed for structures/buildings.
[i] No structural surface derived concentration guideline level (DCGL) was derived for gross beta activity because Ra-228 and lead-210 (Pb-210) were not determined to be significant dose contributors, as detailed in Appendix B of the RI WP; therefore, all beta-emitting PCOCs are accounted for in the gross alpha DCGL. No BV is available.
$SOR_N$ = Sum of ratios (net).
NA = Not applicable.

### 4.1.1 Radiological Screening Levels

To develop the radiological screening levels for evaluating potentially impacted areas for this OU, existing regulations were reviewed. Although the SLDS is not a designated processing site pursuant to the Uranium Mill Tailings Radiation Control Act, USACE previously determined that regulations promulgated by 40 *CFR* Part 192 for cleanup of residual radium and thorium in soil are relevant and appropriate to the characterization of radium and thorium in accessible soil at the SLDS (USACE 1998a). Using this determination for screening of inaccessible soil data at the SLDS and given that the Ra-226 screening levels are specified in 40 *CFR* 192 and that in-growth of Ra-226 occurs based on the decay of Th-230, screening levels have been established for both Ra-226 and Th-230 for the top 0.5 ft of soil [5 picocuries per gram (pCi/g)] and soil below 0.5 ft from the soil surface (15 pCi/g) during this RI. In addition, given the demonstrated protectiveness of the 50 pCi/g U-238 standard used at both the SLDS and the NC sites, a screening level of 50 pCi/g has been established for U-238 for both surface and subsurface soil for data evaluation.

To evaluate the presence of radiological contamination from multiple radiological contaminants, the sum of ratios (SOR) method is applied as the screening level. The $SOR_N$ [note: the subscript "N" denotes "net" (i.e., above background) concentrations] is calculated for each soil sample as the sum of the ratios of radionuclide concentrations (minus mean background concentrations) to the corresponding screening levels. The background values for radionuclides used were determined from 32 soil samples collected from 12 locations in the vicinity of the SLDS, as discussed in the *Background Soils Characterization Report for the St. Louis Downtown Site* (USACE 1999a), and are shown in Table 4-1.

The $SOR_N$ calculations using the above-stated screening levels and background values are defined below. If the result of the $SOR_N$ calculation is greater than or equal to unity (1.0), then the mixture of radionuclides is considered to exceed the soil radiological screening level.

$$SOR_{N\,top\,0.5\,ft.} = \left[\frac{(greater\ of\ Th-230_N\ or\ Ra-226_N)}{5\,pCi/g}\right] + \left[\frac{(greater\ of\ Th-232_N\ or\ Ra-228_N)}{5\,pCi/g}\right] + \left[\frac{U-238_N}{50\,pCi/g}\right]$$

$$SOR_{N\,below\,0.5\,ft.} = \left[\frac{(greater\ of\ Th-230_N\ or\ Ra-226_N)}{15\,pCi/g}\right] + \left[\frac{(greater\ of\ Th-232_N\ or\ Ra-228_N)}{15\,pCi/g}\right] + \left[\frac{U-238_N}{50\,pCi/g}\right]$$

For structures, the screening levels were the derived concentration guideline levels (DCGLs) determined for gross alpha and beta activity, as presented in Table 4-1. However, ultimately, the DCGL was based on only gross alpha. No structural surface DCGL was derived for gross beta activity because Ra-228 and lead-210 (Pb-210) were not determined to be significant dose contributors as detailed in Appendix B of the RI WP (USACE 2009a); therefore, all beta-emitting PCOCs are accounted for in the gross alpha DCGL. The gross alpha DCGL is based on radionuclide-specific DCGLs using average soil concentrations from the 1993 BRA (DOE 1993) based on methods prescribed in *Derivation of Site-Specific DCGLs for North County Structures* (USACE 2004a). Radionuclide-specific DCGLs, each of which equates to the lower of a CR of 1E-06 or a dose limit of 25 millirem per year (mrem/yr) to an industrial worker (i.e., determined to be the limiting receptor for the SLDS), were derived using the Residual Radioactivity (model) (RESRAD)-BUILD computer code from dose-to-source ratios (DSRs) determined for individual radionuclides. The survey results are gross measurements that do not take into account the naturally occurring radioactivity of the various building materials. A detailed description of the calculation process for determining DCGLs for structure surfaces, along with RESRAD-BUILD outputs, is presented in Appendix B of the RI WP (USACE 2009a).

### 4.1.2 Metal Screening Levels

Chemical-specific screening levels for characterizing metals contamination of inaccessible soil are shown in Table 4-1 and are based on the current and expected future land use of the SLDS, which has been identified as heavily industrial within an urbanized setting (DOE 1993). The metal screening levels for soil were originally derived in the 1998 FS (USACE 1998b) for arsenic, cadmium, and elemental uranium. The screening levels for all three metal PCOCs are risk-based and target a non-carcinogenic hazard index (HI) of 1.0. However, all three values were revised in the 1998 ROD (USACE 1998a) due to an erroneous ingestion rate assumed in the 1998 FS for industrial workers.

Although metals background soil data exist, for consistency with CERCLA they are not applied in the same manner as the radiological background values. In other words, background values are not subtracted from ISOU sample concentrations to determine net concentrations. Also, metals background values are not used for eliminating metals from further evaluation in the BRA. A metal is retained for further evaluations in the BRA if the concentration exceeds the corresponding screening level regardless of background comparisons. Additionally, for many metals and other chemicals, it is common for risk-based screening levels to be less than corresponding background levels. This is because risk-based screening levels only consider protection from health effects due to exposure and do not consider background. Also, it is not uncommon for naturally occurring background concentrations to be associated with a health risk. For consistency with the CERCLA approach, it is not until after risk characterization in the BRA where background values may be used as a criterion, in conjunction with other criteria, for identifying risk driver metals as COCs. Further considerations of site-specific background relative to risk-based RGs are also evaluated in the FS. This is because it may not be possible to remediate a metal to meet a risk-based RG that is less than the naturally-occurring background concentration.

Chemical-specific screening levels for sewer sediment and soil adjacent to sewers are presented in Table 4-1 for characterizing metals contamination associated with former MED/AEC activities (e.g., arsenic, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, thorium, vanadium, and zinc). The screening levels presented and applied are the most current values presented in USEPA's regional screening levels (RSLs) tables. Because the ISOU CSM shows a potential for worker contact with sewer sediment, as well as with soil adjacent to sewer lines, the risk-based RSLs being applied for evaluating these media are industrial soil RSLs that target a CR and non-cancer HI of 1E-06 and 1.0, respectively.

Inaccessible soil evaluated for nature and extent of contamination included data collected from the RI sampling activities as well as inaccessible soil data collected from previous characterization activities at the SLDS. Previous characterization activities included soil sampling at locations within the typical inaccessible soil area boundary (e.g., the building foundation and extending out 5 ft). However, data collected during pre-1990 investigations (BNI 1989c; BNI 1989e; BNI 1990a) were not included for the RI evaluation. Although the RI WP used the pre-1990 data to identify potential areas for investigation, the sampling locations were not defined according to the Missouri State Plane Coordinate System, and sampling results could not be replicated. Therefore, for this RI Report, only samples collected at locations identified to the Missouri State Plane Coordinate System were used to define nature and extent. Additionally, although historic sewer sediment data were used to define some locations for sampling in the RI WP, the data were not included in the RI evaluation of nature and extent because of the changing conditions of the sewer system under operational use. Historic building survey data were only available for Building 25 at Plant 1 and some rooftops at Plants 1 and 2 and, likewise, these data were only used for planning potential sampling locations. Only survey data collected during the RI were used to define nature and extent of contamination on buildings.

## 4.2 NATURE AND EXTENT OF CONTAMINATION IN INACCESSIBLE SOIL ASSOCIATED WITH BUILDINGS

RI sampling activities for inaccessible soil associated with buildings were determined on a property-by-property basis using various information, including the MED/AEC historical activities conducted at the property, the results of previous sampling data, and the construction date of the structure (USACE 2009a). The locations where MED/AEC activities were conducted at the property, or where accessible soil may have been excavated under the 1998 ROD, or buildings that were constructed after MED/AEC operations were identified for inaccessible soil sampling. The evaluation of each property indicated that RI sampling was necessary at several Mallinckrodt Plant Areas, VPs, levee areas, RRs, and roadways. No additional sampling for inaccessible soil was required at Gunter Salt (DT-4) South, Midtown Garage (DT-29), Hjersted (DT-24), the South of Angelrodt Property Group (DT-5, DT-13, DT-14, DT-16, DT-17, and DT-18) or the West of Broadway Property Group (DT-20, DT-21, DT-22, DT-23, DT-24, DT-25, DT-26, DT-27, DT-28, DT-20, DT-31, DT-35, DT-36), and the Mallinckrodt Parking Lots (Figure 1-2) (USACE 2009a).

Sampling was conducted in accordance with the RI WP (USACE 2009a) with very few modifications to the sampling locations. The primary reason the locations were moved was due to the presence of utilities at the proposed location or auger refusal. The change in locations was typically minor (<10 ft) which is not likely to impact the results of the RI.

The results of this RI sampling for inaccessible soil are discussed in this section by Plant area or VP. Table 4-2 presents the summary of radiological COC data and Table 4-3 presents the summary of metals COC data at those locations where sampling was conducted. Soil samples collected as part of the ISOU RI as well as those previously collected and within the horizontal boundary (footprint) of the building, levee, RR, or roadway are shown on figures provided in Appendix C. The Appendix C figures also identify locations where PCOC screening levels were exceeded for inaccessible soil areas. The GWS data collected for each inaccessible soil area are presented in Appendix D. The analytical results for soil sampling are presented in Appendix E.

### 4.2.1 Mallinckrodt Plant 1

One hundred ninety-one soil samples were collected during the RI from systematic, random, and biased sampling locations at Buildings C, G, L, X, 8, 25, 26, 27, 28, and 29, at the walkway between Buildings L and Z, at the Southeast Containment Pad, and at the Building 6 containment pad as shown on Figure C-1. The results of these samples, as well as existing data, were used to evaluate the extent of radiological contamination. Radiological contamination above the screening level was identified in 12 discrete areas associated with 5 of the buildings investigated (Building 8, 25, 26, X, and the Southeast Containment Pad). The following section presents a description of Plant 1, detailed sampling information on an area-by-area basis, and a summary of the results. No other soil areas associated with buildings in Plant 1 require further evaluation.

#### *4.2.1.1 Description of Plant 1*

Plant 1 was originally part of Mallinckrodt's "Main Plant," and is an approximately 6.5-acre area located in the central portion of the Mallinckrodt property (Figure 1-2). Plant 1 currently consists of over 20 buildings and structures and a variety of structures such as tanks, containment pads, walkways, a loading dock, and stairways. In 2009, Buildings F and G were demolished by Covidien as part of their facilities management; however, the foundations remain. On the eastern edge of the plant, a RR spur enters the property from DT-9 (Figure C-1).

Plant 1 was used by MED/AEC for small-scale developmental work in refining triuranium octoxide feed and experimental processing of radium-containing pitchblende ores from 1942 to 1945. The MED/AEC work at Plant 1 was performed in four pre-existing Mallinckrodt structures: Buildings 25, A, K, and X (Figure 1-3). Of these four structures, only Buildings 25 and X remain today. Two laboratory areas inside Building 25 were used to develop uranium-processing methods on a small scale for MED/AEC. Building 25 also contained the MED/AEC project offices. Additionally, MED/AEC work was conducted for several months during 1942 in the alley adjacent to the south side of Building 25. Building X housed locker rooms for employees supporting MED/AEC operations. Building K was formerly located in the area identified as the Building K excavation area, and Building A was located where Building 27 exists today (Figure C-1). The rest of the buildings currently located at Plant 1 consist of office buildings, a cafeteria, warehouses, production facilities, and miscellaneous structures associated with Covidien's general (non-MED/AEC) manufacturing business. With the exception of Buildings 5, 26, 27, 28, and 29, the existing buildings at Plant 1 were built prior to MED/AEC operations.

Buildings B, F, P, Z, 3, 4, 5, 6, 7, 10, 10A, 16, and 17 were constructed prior to MED/AEC activities and there was no soil remediation adjacent to these buildings. Additionally, samples previously collected within the footprints of Buildings 3 and P were below the screening level (Figure C-1). Therefore, the inaccessible soil beneath Buildings B, F, P, Z, 3, 4, 5, 6, 7, 10, 10A, 16, and 17 is classified as non-impacted. See Section 4.1.1 of the RI WP for more details. Any MED/AEC sewers located near or beneath these buildings were evaluated as part of this RI and are discussed in Section 4.7. RI characterization activities were conducted at Buildings C, G, L, X, 8, 25, 26, 27, 28, 29, the Building L and Z Walkway, the Southeast Containment Pad, and the Building 6 containment pad.

Building 25 is the only building in Plant 1 that is specifically discussed in the 1998 ROD as being addressed under a separate CERCLA action. The 1998 FS (in referring to 40 CFR 192 external gamma radiation guidelines) states that "*Building 25 is an active operational facility in which the surface criteria were exceeded in some areas. Since the RI, extensive remodeling and painting has resulted in a reduction in the potential for employee exposures.*" Also, the 1998 ROD states "*Radon in buildings 25 and 101 overlying inaccessible soil will be controlled through active and passive radon reduction measures until a remedy for the inaccessible soils unit is selected.*" Soil samples had not been collected under Building 25 at the time the 1998 FS and 1998 ROD were drafted. Building 101 in Plant 6 is scheduled to be razed.

*4.2.1.2 Nature and Extent of Contamination at Plant 1*

This section presents the results of the RI sampling of inaccessible soil areas at Plant 1.

Plant 1 was not considered a uranium-ore processing area in the 1998 ROD. Therefore, data evaluation for the ISOU for Plant 1 included only radiological PCOCs.

Inaccessible soil samples were collected from systematic, random, and biased sampling locations at Plant 1 as shown on Figure C-1. The GWSs conducted at the buildings proposed for soil sampling are presented on Figure D-1-1 through D-1-11. A summary of the radiological concentrations in inaccessible soil at Plant 1 is shown in Table 4-2. The analytical results and $SOR_N$ values for each sample collected at Plant 1 during this RI are presented in Table E-1.

**Buildings C, G, L, 27, 28, and 29 and the L and Z Walkway:** Soil samples from systematic and random sampling locations proposed for the inaccessible soil at Buildings C, G, L, 27, 28, 29, and Building L and Z Walkway were collected and analyzed for radiological PCOCs. Soil samples from within the footprints of Buildings C, G, and L were collected to evaluate the lateral extent of contamination that may be present due to the accessible soil excavations conducted adjacent to the buildings, specifically at Building K Excavation area and south of Building G. Soil at Buildings 27, 28, and 29 was sampled because these buildings were not present during the MED/AEC period. The walkway between Buildings L and Z was characterized because historic characterization data (1989) indicated radiological contamination was present (as evidenced by an $SOR_N$ value >1.0) in inaccessible soil beneath the walkway. The GWS identified no areas warranting additional soil samples.

**Table 4-2. Summary of Radiological Concentrations in Inaccessible Soil at the St. Louis Downtown Site for Potential Contaminants of Concern [a]**

| Location | Ra-226 (pCi/g) | | | | Ra-228 (pCi/g) | | | | Th-228 (pCi/g) | | | | Th-230 (pCi/g) | | | | Th-232 (pCi/g) | | | | U-235 (pCi/g) | | | | U-238 (pCi/g) | | | | $SOR_N$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Average | Minimum | Maximum | Total # of Samples | Average | Minimum | Maximum | Total # of Samples | Average | Minimum | Maximum | Total # of Samples | Average | Minimum | Maximum | Total # of Samples | Average | Minimum | Maximum | Total # of Samples | Average | Minimum | Maximum | Total # of Samples | Average | Minimum | Maximum | Total # of Samples | Average | Minimum | Maximum | Total # of Samples |
| Plant 1 | 6.58 | 0.39 | 623.00 | 279 | 0.82 | ND | 2.15 | 279 | 1.12 | ND | 3.96 | 275 | 8.48 | ND | 505.00 | 279 | 0.95 | ND | 3.38 | 279 | 0.72 | ND | 17.40 | 275 | 13.05 | ND | 316.00 | 279 | 0.96 | 0.0 | **41.35** | 279 |
| Plant 2 | 1.72 | 0.28 | 12.20 | 166 | 0.78 | 0.05 | 13.10 | 166 | 1.14 | ND | 16.30 | 166 | 1.64 | ND | 11.00 | 166 | 0.95 | ND | 12.30 | 166 | 0.51 | ND | 19.80 | 166 | 9.83 | ND | 394.00 | 166 | 0.25 | 0.0 | **8.22** | 166 |
| Plant 3 | 2.06 | 0.93 | 4.70 | 18 | 0.69 | 0.31 | 1.02 | 18 | 1.01 | 0.34 | 1.96 | 18 | 2.18 | 0.97 | 7.13 | 18 | 0.79 | 0.37 | 1.17 | 18 | 0.06 | ND | 0.47 | 18 | 2.54 | 0.90 | 8.24 | 18 | 0.11 | 0.0 | **1.11** | 18 |
| Plant 6 | 3.59 | 0.31 | 57.30 | 63 | 0.74 | 0.15 | 1.34 | 63 | 0.99 | 0.15 | 1.74 | 63 | 2.57 | ND | 44.80 | 63 | 0.88 | 0.07 | 1.80 | 63 | 1.85 | ND | 95.40 | 63 | 36.80 | ND | 1949 | 63 | **1.10** | 0.0 | **49.86** | 63 |
| Plant 7 | 1.91 | 1.29 | 2.93 | 5 | 0.83 | 0.47 | 0.99 | 5 | 1.26 | 0.70 | 1.73 | 5 | 2.47 | 0.93 | 3.84 | 5 | 0.96 | 0.56 | 1.22 | 5 | 0.11 | 0.04 | 0.16 | 5 | 3.34 | 0.91 | 6.26 | 5 | 0.10 | 0.0 | 0.17 | 5 |
| Mallinckrodt Security Gate 49 | 4.13 | 1.30 | 10.30 | 18 | 0.83 | 0.28 | 1.35 | 18 | 1.13 | 0.38 | 2.16 | 18 | 3.82 | 1.26 | 9.01 | 18 | 0.96 | 0.30 | 1.73 | 18 | 0.20 | ND | 0.68 | 18 | 4.85 | ND | 10.90 | 18 | 0.23 | 0.0 | 0.64 | 18 |
| City Property (DT-2) | 3.04 | 0.74 | 66.40 | 257 | 0.93 | 0.07 | 1.79 | 257 | 1.19 | 0.18 | 2.64 | 257 | 2.38 | ND | 11.00 | 257 | 1.03 | ND | 2.51 | 257 | 0.15 | ND | 1.56 | 257 | 2.32 | ND | 12.50 | 257 | 0.13 | 0.0 | **4.31** | 257 |
| Gunther Salt North (DT-4) | 6.27 | 0.50 | 137.00 | 254 | 0.96 | 0.05 | 2.35 | 254 | 1.33 | 0.11 | 3.06 | 254 | 30.63 | ND | 1462.00 | 254 | 1.10 | 0.04 | 2.50 | 254 | 2.63 | ND | 81.30 | 254 | 46.67 | 0.16 | 1626.00 | 254 | **3.03** | 0.0 | **102.56** | 254 |
| Heintz Steel and Manufacturing (DT-6) | 3.90 | 0.60 | 31.50 | 136 | 0.84 | 0.17 | 2.32 | 136 | 1.22 | 0.22 | 3.34 | 136 | 3.86 | ND | 569.00 | 136 | 0.98 | 0.25 | 2.78 | 136 | 0.80 | ND | 13.77 | 136 | 13.75 | 0.55 | 244.74 | 136 | 0.79 | 0.0 | **39.19** | 136 |
| PSC Metals, Inc. (DT-8) | 2.33 | 0.50 | 12.70 | 297 | 0.74 | ND | 2.44 | 297 | 0.94 | ND | 3.22 | 297 | 1.54 | ND | 10.90 | 297 | 0.80 | ND | 2.44 | 297 | 0.14 | ND | 1.19 | 297 | 2.59 | ND | 21.40 | 297 | 0.12 | 0.0 | **1.63** | 297 |
| Thomas and Proetz Lumber Company (DT-10) | 3.91 | 0.96 | 9.70 | 47 | 0.77 | 0.12 | 1.36 | 47 | 0.99 | 0.09 | 1.89 | 47 | 3.65 | 0.78 | 9.53 | 47 | 0.87 | 0.17 | 1.73 | 47 | 0.38 | ND | 1.98 | 47 | 6.08 | 0.83 | 34.70 | 47 | 0.23 | 0.0 | 0.99 | 47 |
| MSD Lift Station (DT-15) | 1.90 | 1.02 | 7.21 | 44 | 0.88 | 0.33 | 1.96 | 44 | 1.13 | 0.45 | 2.02 | 44 | 1.97 | 0.95 | 7.80 | 44 | 0.99 | 0.24 | 2.32 | 44 | 0.09 | ND | 0.75 | 44 | 1.51 | 0.13 | 4.99 | 44 | 0.04 | 0.0 | 0.54 | 44 |
| Norfolk Southern RR (DT-3) | 2.53 | 0.50 | 12.80 | 351 | 1.04 | 0.07 | 28.10 | 351 | 1.25 | 0.12 | 27.70 | 351 | 2.70 | 0.36 | 29.80 | 351 | 1.07 | 0.03 | 24.00 | 351 | 0.20 | ND | 2.12 | 351 | 3.29 | ND | 42.70 | 351 | 0.18 | 0.0 | **7.59** | 351 |
| Terminal RR Rail Yard (DT-9) | 5.69 | 0.45 | 191.00 | 214 | 0.92 | 0.04 | 2.55 | 214 | 1.13 | 0.05 | 2.84 | 214 | 5.83 | 0.62 | 272.00 | 214 | 0.98 | ND | 2.73 | 214 | 0.35 | ND | 12.30 | 214 | 5.50 | 0.37 | 177.00 | 214 | 0.66 | 0.0 | **29.84** | 214 |
| Terminal RR Levee (DT-9) | 1.40 | 0.65 | 3.48 | 132 | 0.88 | 0.06 | 1.58 | 132 | 1.09 | 0.02 | 1.97 | 132 | 1.44 | 0.50 | 4.76 | 132 | 0.98 | 0.09 | 1.81 | 132 | 0.05 | ND | 0.46 | 132 | 1.27 | ND | 3.88 | 132 | 0.02 | 0.0 | 0.27 | 132 |
| Terminal RR Main Line (DT-9) | 2.37 | 0.61 | 28.20 | 454 | 0.85 | 0.01 | 64.80 | 454 | 1.11 | 0.06 | 64.80 | 454 | 2.42 | 0.54 | 71.50 | 454 | 0.97 | 0.05 | 64.80 | 454 | 0.13 | ND | 1.41 | 454 | 2.09 | ND | 14.30 | 454 | 0.11 | 0.0 | **9.13** | 454 |
| Terminal RR Spoils Area | 2.76 | 0.67 | 16.90 | 56 | 0.70 | 0.11 | 2.60 | 56 | 0.93 | 0.04 | 2.60 | 56 | 9.26 | 0.58 | 260.00 | 56 | 0.76 | 0.05 | 2.60 | 56 | 0.33 | ND | 8.60 | 56 | 6.45 | ND | 179.00 | 56 | **1.39** | 0.0 | **55.49** | 56 |
| BSNF RR (DT-12) | 2.03 | 0.32 | 8.95 | 480 | 0.65 | 0.03 | 1.80 | 480 | 0.85 | ND | 2.86 | 480 | 3.47 | 0.26 | 53.90 | 480 | 0.73 | ND | 1.74 | 480 | 0.16 | ND | 1.82 | 480 | 2.83 | 0.14 | 33.50 | 480 | 0.33 | 0.0 | **10.71** | 480 |
| North Second Street | 2.41 | 0.87 | 10.30 | 81 | 0.78 | 0.26 | 1.44 | 81 | 1.03 | 0.17 | 1.95 | 81 | 3.07 | 1.02 | 27.10 | 81 | 0.93 | 0.21 | 1.73 | 81 | 0.20 | ND | 1.80 | 81 | 3.66 | ND | 26.90 | 81 | 0.15 | 0.0 | **2.04** | 81 |
| Hall Street | 2.89 | 0.47 | 85.20 | 255 | 0.80 | 0.14 | 2.09 | 255 | 1.04 | 0.14 | 2.37 | 255 | 4.02 | ND | 54.40 | 255 | 0.91 | ND | 1.90 | 255 | 0.28 | ND | 9.84 | 255 | 4.56 | ND | 190.00 | 255 | 0.28 | 0.0 | **9.98** | 255 |
| Bremen Avenue | 1.09 | 0.45 | 1.47 | 33 | 0.74 | 0.10 | 1.26 | 33 | 0.96 | 0.10 | 1.95 | 33 | 1.18 | 0.30 | 1.94 | 33 | 0.85 | 0.10 | 1.63 | 33 | 0.06 | ND | 0.33 | 33 | 0.96 | ND | 2.57 | 33 | 0.01 | 0.0 | 0.05 | 33 |
| Salisbury Street | 1.33 | 0.47 | 3.18 | 18 | 0.63 | 0.12 | 1.39 | 18 | 0.86 | 0.22 | 1.73 | 18 | 1.34 | 0.30 | 2.67 | 18 | 0.65 | ND | 1.26 | 18 | 0.05 | ND | 0.25 | 18 | 1.05 | 0.09 | 3.37 | 18 | 0.01 | 0.0 | 0.06 | 18 |
| Mallinckrodt Street | 1.46 | 0.50 | 3.93 | 70 | 0.73 | 0.18 | 1.70 | 70 | 1.07 | 0.25 | 3.95 | 70 | 2.30 | 0.61 | 13.90 | 70 | 0.98 | 0.09 | 3.39 | 70 | 0.20 | ND | 2.38 | 70 | 3.36 | ND | 50.30 | 70 | 0.17 | 0.0 | **1.88** | 70 |
| Destrehan Street | 2.64 | 0.60 | 25.10 | 248 | 0.83 | 0.07 | 7.35 | 248 | 1.13 | 0.24 | 8.03 | 248 | 4.64 | ND | 411.00 | 248 | 1.00 | 0.09 | 8.61 | 248 | 0.22 | ND | 4.48 | 248 | 4.61 | ND | 75.90 | 248 | 0.30 | 0.0 | **27.39** | 248 |
| Angelrodt Street | 2.91 | 0.91 | 14.30 | 106 | 0.76 | 0.20 | 1.38 | 106 | 1.04 | 0.23 | 2.32 | 106 | 3.16 | 0.87 | 46.40 | 106 | 0.88 | 0.14 | 1.74 | 106 | 0.13 | ND | 0.79 | 106 | 2.44 | ND | 9.33 | 106 | 0.14 | 0.0 | **2.96** | 106 |
| Buchanan Street | 2.62 | 0.53 | 6.30 | 60 | 0.77 | 0.13 | 1.32 | 60 | 1.12 | 0.18 | 2.55 | 60 | 2.57 | 0.87 | 7.21 | 60 | 0.90 | 0.04 | 1.88 | 60 | 0.20 | ND | 1.84 | 60 | 2.96 | 0.05 | 33.70 | 60 | 0.14 | 0.0 | 0.75 | 60 |

[a] This table does not include data for inaccessible soil adjacent to sewer lines

ND = Not detected at the method detection limit.

**Bold** values indicate samples collected at the property that exceeded $SOR_N$ screening levels.

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## Table 4-3. Summary of Metal Concentrations in Inaccessible Soil for Properties Within the Uranium-Ore Processing Area[a,b]

| Location | Arsenic (mg/kg) | | | | Cadmium (mg/kg) | | | | Uranium (mg/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ISOU Screening Level = 60 mg/kg | | | | ISOU Screening Level =17 mg/kg | | | | ISOU Screening Level = 3,100 mg/kg | | | |
| | Average | Minimum | Maximum | Total # of Samples | Average | Minimum | Maximum | Total # of Samples | Average | Minimum | Maximum | Total # of Samples |
| Plant 2 | 6.19 | 2.70 | 10.5 | 7 | 1.14 | 0.12 | 3.60 | 7 | 10.5 | 5.60 | 14.9 | 7 |
| Plant 6 | 7.19 | 3.50 | 15.1 | 8 | 0.55 | 0.03 | 0.80 | 8 | 24.0 | 5.70 | 62.1 | 7 |
| Thomas and Proetz (DT-10) | 49.2 | 0.74 | **178** | 8 | 1.88 | 0.76 | 3.30 | 8 | 53.6 | 12.0 | 104 | 8 |
| Terminal RR (DT-9) | 6.87 | 2.80 | 14.6 | 18 | 5.61 | 0.60 | **69.3** | 18 | 41.5 | 5.90 | 68.2 | 18 |
| BNSF RR (DT-12) | 108 | 1.50 | **543** | 34 | 2.35 | 0.48 | 6.70 | 34 | a | a | a | a |
| Hall Street | 7.27 | 3.60 | 10.0 | 7 | 1.98 | 0.83 | 2.70 | 7 | 39.6 | 7.50 | 84.9 | 7 |
| Destrehan Street | 13.1 | 6.10 | 25.0 | 6 | 0.96 | 0.54 | 2.40 | 6 | 58.5 | 13.4 | 146 | 6 |

**Bold** values indicate samples collected at the property that exceeded ISOU screening levels.

[a] Summary data do not include inaccessible soil associated with sewers (see Table 4-7).

[b] Samples were not collected at Plant 7N or Mallinckrodt Street. Uranium was not analyzed in samples collected at DT-12.

The results showed that $SOR_N$ values in all of the samples collected to a depth of 6.0 ft were less than 1.0.

**Building X:** At Building X, one soil sample (SLD76504) was collected in 2003 within the footprint of the building to a depth of 1.0 ft. The data from the 0 to 0.5-ft sampling interval (below cover) showed elevated concentrations of Th-230 resulting in an $SOR_N$ value of 3.27. During the RI, biased and systematic soil samples were collected to evaluate the extent of potential contamination beneath Building X. One planned soil sample exceeded the $SOR_N$ screening criteria. The soil sample collected at the 0 to 0.5 ft depth interval at SLD126625 has an $SOR_N$ of 9.42. Sampling location SLD126625 was the offset location of the original sample location SLD125593 which had resulted in auger refusal at 1.5 ft below the bottom of the concrete floor. Three additional soil sampling locations (SLD126991, SLD126996, and SLD127000) were chosen based on results of the GWS (Figure D-1-7). The results from these sampling locations show that additional areas of radiological contamination exist beneath Building X to a depth of 1 to 2 ft in the northern and eastern portions of the building. The highest $SOR_N$ value for Building X was 12.1 at SLD127000 collected between 1.0 and 1.5 ft. The GWS of Building X indicated several areas of elevated activity and therefore, a GWS was conducted at Building 3, located west of Building X, to evaluate potential areas of elevated radioactivity (Figure D-1-8). No additional areas warranted biased soil sampling at Building 3.

A small area located south of the Building X loading dock was identified in the *Post-Remedial Action Report for the Accessible Soils within the St. Louis Downtown Site Plant 1 Property, St. Louis, Missouri* (Plant 1 PRAR) (USACE 2004b) as inaccessible and contaminated. One sidewall sample (HTZ00536) was collected during accessible soil remediation to the south of the loading dock. The calculated $SOR_N$ value for this sample was 1.41. During RI characterization, soil sample SLD125569 was collected through the loading dock adjacent to the area of detected contamination and SLD125573 was sampled to the northwest of this area to identify the potential extent of contamination in this area. The $SOR_N$ values ranged between 0 and 0.14 at these sample locations.

**Building 8:** Accessible soil remediation was conducted to the west of Building 8 and, therefore, soil within the footprint of Building 8 was sampled at the locations shown on Figure C-1. A GWS was conducted at Building 8; the substation area to the west of Building 8; and at the adjacent buildings to the east (Buildings 6 and 7) (Figure D-1-9). One additional sample location between Buildings 7 and 8 was selected (SLD127053) based on the results of the GWS. The results of soil sampling at Building 8 indicate that the radiological contamination extends beneath the northern portion of Building 8 at two locations (SLD125525 and SLD125529). The highest $SOR_N$ value at location SLD125525 was 15.6, from the deepest sample (4.5 to 5 ft) collected at this location. Deeper sampling could not be conducted due to the soil borehole collapsing. At sample location SLD125529, the highest $SOR_N$ value was 36.6 at a depth of 1 to 1.5 ft. This location was sampled to a depth of 9.5 ft and at this interval, the $SOR_N$ value was 1.13. At the remaining four locations that were sampled in the southern and eastern portions of Building 8, the $SOR_N$ values were all less than 1.0. Additionally, the results from sample locations SLD127053 and SLD126616 indicate that the extent of contamination is limited to the northwestern area of Building 8. This detected area of contamination may be due to the sewer that traverses beneath the building in this area. Plant 1 sewers are addressed in Section 4.7.2.

Three areas west of Building 8 were defined as inaccessible areas of detected contamination in the Plant 1 PRAR (USACE 2004b). The inaccessible area located near the northwest corner of Building 8 is adjacent to the "Bent 11 excavation" per the Plant 1 PRAR (USACE 2004b). Sidewall samples (HTZ00493 and HTZ00494) collected from the accessible soil excavation in this area have calculated $SOR_N$ values of 1.97 and 1.33, respectively. Another inaccessible area is located beneath a stair-support column footing in Area 3A west of Building 8, as defined in the Plant 1 PRAR (USACE 2004b), and samples HTZ00203 and HTZ00298 (from location HTZ00170) are used to evaluate the radiological contamination in that area. HTZ00203 and HTZ00298 have calculated $SOR_N$ values of 4.52 and 1.10, respectively. The third inaccessible area west of Building 8 is located beneath the containment curb adjacent to a substation in Area 3. The sample collected in this area (HTZ00299) had an $SOR_N$ value of 1.29. Southwest of this inaccessible area, location SLD02400 also was previously sampled and was below the screening level. During this RI, one soil sample was collected at location SLD125521 and was below the screening level. The GWS was conducted in the substation area west of Building 8 indicated elevated radioactivity in the containment curb adjacent to the substation. Sampling could not be conducted in this area to bound the western extent of contamination due to operational use of the structure.

**Buildings 25 and P:** Soil from systematic and biased soil sampling locations was collected as proposed in the RI WP. At several of the locations, auger refusal was encountered during sampling at depths of approximately 1.5 to 2.0 ft; therefore, the location was offset slightly and drilling continued. Soil samples from all locations were analyzed regardless of sampling depth obtained. A GWS was conducted within the footprint of Buildings 25 and P and the results indicated that there were four small areas of elevated gamma activity in the southwestern portion of Building 25 (Figure D-1-10). Sample SLD127046 was collected from the area indicating the greatest activity from the GWS. The data from the RI soil sampling conducted at Building 25 did not exceed the screening level. The sample previously collected by Building P did not exceed the screening level.

During accessible soil remediation adjacent to the southwestern corner of Building 25 six horizontal borings were sampled beneath the foundation as part of the USACE's Preferential Pathway Analysis (IT 2001b; IT 2001c). The accessible soil remediation area and the horizontal boring sample locations are shown on Figure C-1. The boring locations were approximately 1.5 ft below the foundation and extended under the southwest corner of Building 25 to a horizontal depth of approximately 5 ft. One of the six horizontal borings indicated that contamination extended beneath the building. Sample SLD28640 has an $SOR_N$ of 6.1 indicating contamination extending to a horizontal depth of 2.5 ft. The soil samples collected during the RI at locations SLD125449 and SLD126601 inside the building indicate that the extent of contamination is limited to the edge of the foundation.

The preferential pathway investigation, which used horizontal boring data under the southeast corner of Building 25, indicated that uranium contamination had only migrated approximately 2.5 ft beneath Building 25. The preferential pathway investigation indicated that Ra-226, which decays to radon-222 (Rn-222), was at background concentrations. The systematic and biased samples collected beneath Building 25 during the RI have net Ra-226 concentrations less than 2 pCi/g. The Ra-226 results support the conclusion that elevated radon concentrations due to residual radium is not present at levels such that it could be of concern.

**Building 26:** Building 26, located in the southeastern corner of Plant 1 (Figure C-1), was built after MED/AEC operations ceased, and is adjacent to an accessible soil remediation area. Previous characterization activities at Plant 1 indicated radiological contamination was present (as evidenced by an $SOR_N$ value >1.0) in inaccessible soil beneath Building 26. Several soil samples were collected in 2002 beneath this building to a depth of approximately 2.2 ft. Four of the six sampling locations (SLD68593, SLD68594, SLD68595, and SLD68694) had elevated concentrations of Ra-226 and Th-230 resulting in $SOR_N$ values between 1.10 and 41.4. A GWS was conducted within the interior of Building 26 and is presented on Figure D-1-11. The GWS identified no areas warranting additional soil samples.

**Building K Excavation Inaccessible Soil Areas:** The Building K accessible soil excavation is shown on Figure C-1 and had a maximum depth of approximately 12 ft. During accessible soil remediation, soil samples were collected within the sidewalls of the excavation to identify the level of radiological contamination. Three inaccessible areas of detected contamination were identified in the Plant 1 PRAR (USACE 2004b) and are shown on Figure C-1. The $SOR_N$ value from the sample collected at the northeastern corner at location P-1 was 6.29. The $SOR_N$ values from three samples collected at the southeast corner (HTZ00682, HTZ00687, and P1UE321) ranged between 2.38 and 4.81. The $SOR_N$ values for the three samples collected at the southwest corner (P1-UE4-018, P1-UE4-019, and P1-UE4-020) are 8.43, 2.91, and 0.70, respectively.

Inaccessible area soil samples were collected from under Buildings C and L adjacent to the Building K excavation. The results of the soil sampling at Buildings C and L indicated that all of the $SOR_N$ values were less than 1.0. Additionally, one sampling location was selected (SLD125473) in the area between the excavation and Building C (Figure C-1). SLD125473 was sampled to 5.5 ft and the results indicated $SOR_N$ values less than 1.0. Additional sampling adjacent to Building C and L may be required to vertically delineate contamination in this area for risk evaluation.

**Building 6 Containment Pad:** Sampling was conducted in the inaccessible soil area at the containment pad east of Building 6. Two of the three samples were collected to a depth of 6 ft, as proposed in the RI WP (USACE 2009a) to investigate an inaccessible area of detected contamination, east of the containment pad, identified during accessible soil remediation. The maximum $SOR_N$ value calculated for these samples (SLD125549 and SLD125553) was 0.15. The third sample was not collected because the containment pad was in use and Covidien would not allow sampling. The data from three soil samples (SLD67509, SLD67510, and SLD67511) collected during accessible soil remediation activities in the western side wall of the excavation indicated that the area was not above inaccessible soil screening levels. The samples were collected between 0 and 0.5 ft below the containment pad and the calculated $SOR_N$ values ranged from 0.12 to 0.25. These sampling results indicate that the soil associated with the Building 6 containment pad is below the screening level. The GWS did not indicate areas warranting additional soil samples.

**Southeast Containment Pad:** Sampling was conducted to investigate the inaccessible area of detected contamination defined north of the pad. At the southeast containment pad, one sample was previously collected (SLD02424) in 1999 and the calculated $SOR_N$ value was 0.16 (USACE 2009a). Soil sampling was proposed in the RI WP to evaluate whether contamination extended further below the pad. The proposed sampling could not be conducted within the containment pad, which is a confined space, because it is in use.

At the inaccessible area of detected contamination defined north of the pad, soil samples HTZ00515, HTZ00527, and HTZ00462, collected in the sidewall of the accessible soil excavation to the north, indicated elevated radiological concentrations remaining in this small inaccessible soil area. The calculated $SOR_N$ values for these three samples ranged from 1.10 to 4.54.

#### *4.2.1.3 Summary of Plant 1 Inaccessible Soil Results*

The inaccessible soil areas in Plant 1 that exceed the screening level include a small area under Building 25, three areas adjacent to the Building K excavation, two areas adjacent to the west side of Building 8, one small area within an electrical substation containment area west of

Building 8, an area beneath the northern portion of Building 8, an area beneath Building 26, a small area adjacent to the Southeast Containment Pad, a small area adjacent to the loading dock south of Building X, and two areas beneath Building X. These areas are further evaluated in the BRA. See Figure C-1 for the inaccessible areas and samples that exceed the screening level. No other soil areas associated with buildings in Plant 1 require further evaluation.

### 4.2.2 Mallinckrodt Plant 2

One hundred seventy-four soil samples were included in the RI evaluation. Samples were collected as described in Section 2.2, from systematic, random, and biased sampling locations at Buildings 40/41/506/508 complex; south of Building 509, Buildings 501, 503, 504, 505, and 510; and the southeastern corner of Plant 2, as shown on Figure C-2. The results of the RI samples, as well as existing data, were used to evaluate the extent of radiological contamination in inaccessible soil areas. Radiological contamination above the screening level was identified in 4 discrete areas associated with (1) Building 508, (2) south of the 50-series excavation, (3) northwest of the 50-series excavation and (4) the southeast corner of Plant 2. No metal PCOCs were detected above screening levels in the samples collected at Plant 2. The following section presents a description of Plant 2, detailed sampling information on an area-by-area basis, and a summary of the results.

#### *4.2.2.1 Description of Plant 2*

Plant 2 is centrally located within the Mallinckrodt property (Figure 1-2) and was used by MED/AEC for the processing of uranium feed materials and temporary storage of residues. Uranium refining operations began at Plant 2 in April 1942, producing approximately 4,400 tons of $UO_2$. Facilities for batch production were installed in Buildings 50, 51, 51A, 52 and 52A to produce $UO_3$ from ore concentrates. These buildings, the 50-series buildings, once stood in the central portion of Plant 2 (Figure 1-3). Buildings 40, 45, 45A and 47 were used as warehouse buildings for raw, in-process, and finished materials. Work at Plant 2 ended in 1946 when the plant was closed and the work moved to the newly built Plant 6.

Twelve buildings currently exist at Plant 2, including the larger buildings (501, 502, 503, 504, 505, 507, 509, and 510) and a complex of smaller buildings (40, 41, 506, and 508) (Figure C-2). All of the current buildings at Plant 2 were constructed after MED/AEC operations ceased, except for Buildings 501 and 41. Former Building 40 was used during MED/AEC operations for temporary storage of residues and was torn down during 1978 and 1979. The current Building 40 is located in approximately the same location. Building 506 was once located closer to Building 508 but was reconstructed to the south as shown on Figure C-2. In the eastern portion of Plant 2, RR spurs, which were present during MED/AEC operations, enter into the plant from the Terminal RR (DT-9).

Remediation of accessible soil did not occur adjacent to Buildings 502, 507, and 509. The evaluation of the existing soil sample data adjacent to Building 502, 507, and 509 indicates that the soil is non-impacted (Figure C-2). Any MED/AEC sewers located near or beneath these buildings were evaluated as part of this RI and are discussed in Section 4.7.3. RI characterization activities were conducted at Buildings 40/41/506/508 complex; Buildings 501, 503, 504, 505, and 510; and the southeastern corner of Plant 2, as shown on Figure C-2. The RR spurs located at Plant 2 were already characterized as part of the accessible soil remediation efforts and found to be below accessible soil RGs.

#### *4.2.2.2 Nature and Extent of Contamination at Plant 2*

This section presents the results of the RI sampling of inaccessible soil areas at Plant 2.

Plant 2 is defined as being within the uranium-ore processing area, and therefore, soil samples collected for the evaluation at Plant 2 were analyzed for both radiological and metal PCOCs as discussed in Section 2.1.

Inaccessible soil samples were collected from systematic, random, and biased sampling locations at Plant 2 as shown on Figure C-2. The GWSs conducted at the buildings proposed for soil sampling are presented on Figures D-2-1 through D-2-5. A summary of the radiological data from Plant 2 is presented in Table 4-2. A summary of the metals data is presented in Table 4-3. The analytical results and $SOR_N$ values for each sample collected at Plant 2 during this RI are presented in Table E-2 (radiological) and Table E-3 (metals).

**Buildings 40/41/506/508 Complex:** Biased and systematic soil samples were collected at the locations shown on Figure C-2. A GWS within the footprint of the Buildings 40/41/508 complex was conducted and no additional soil sampling was conducted based on the results (Figure D-2-1). Building 506 was relocated approximately 25 ft to the south in an area that was cleared for release under the 1998 ROD (USACE 1998a). Therefore, the previous Building 506 footprint area was investigated by GWS and sampling.

The results of soil sampling show that the radiological contamination above screening levels is present near Building 508 at location SLD125349. The $SOR_N$ values at location SLD125349 for two soil sampling intervals between 3 and 6 ft were 1.42 and 1.50. The surface and deeper subsurface sample $SOR_N$ values at this location (to 9.5 ft) and the other sampling locations (to 6.5 ft) within this building complex were less than 1.0. Soil samples were collected at SLD125345 to characterize metals, and no metal PCOCs were detected above screening levels (Table 4-3). The soil sample collected within the footprint of Building 41 (SLD125341) was below the screening levels.

**Building 501:** A GWS was conducted (Figure D-2-2) and soil samples were collected at several systematic locations to characterize the potential soil contamination beneath Building 501. Soil samples also were collected from two biased sampling locations near a small accessible soil excavation area located on the southeastern side of Building 501. Samples were collected to a depth of 6 ft at SLD125409, but auger refusal at SLD125413 at 4.5 ft required the location to be moved to the outside of the building; sample collection was completed at SLD127202. The results of the inaccessible soil sampling at Building 501 show that all samples were below the radiological screening level. Soil collected at SLD125409 was analyzed for metal PCOCs, and the results did not exceed screening levels.

**Buildings 503, 504, and 505:** Soil was collected at several random sampling locations at Buildings 503, 504, and 505, as shown on Figure C-2. A GWS also was completed at each building with readings at background levels (Figures D-2-3 and D-2-4). Soil samples were collected at Building 503 (SLD125337) and Building 505 (SLD125321) to characterize metals. The soil sampling results for both radiological and metal PCOCs were less than the screening levels.

**Building 510:** Soil was collected at one systematic sampling location within the footprint of Building 510. Additionally, samples were collected at two biased locations to evaluate the potential extent of contamination beneath Building 510 because it is located near the accessible soil 50-series buildings excavation area, which lies just north of Building 510 (Figure C-2). The *Post-Remedial Action Report for the Accessible Soils within the St. Louis Downtown Site Plant 2*

*Property, St. Louis, Missouri* (USACE 2002a) identified an "inaccessible area of detected contamination" between the 50-series building excavation area and Building 510 based on a sidewall sample collected in the excavation (SLD05158) north of Building 510. The calculated $SOR_N$ value at SLD05158 was 4.24. The RI samples adjacent to Building 510 were collected using a hand auger due to the presence of utilities. The RI WP-proposed sampling depth in this area was changed from 23 ft to approximately 6 ft, which is approximately the same depth below cover material of the accessible soil excavation near Building 510 (IT 2000). Soil samples collected from two locations (SLD125365 and SLD125377), one within and one adjacent to Building 510, were analyzed for metal PCOCs. A GWS also was conducted, and no additional areas for sampling were identified due to elevated readings (Figure D-2-5).

The analytical results for soil samples collected within the Building 510 footprint show that all radiological and metal PCOCs were below screening levels. Additionally, one soil sample (SLD125385) collected between Buildings 501 and 510 (Figure C-2) was collected to a depth of 20 ft as part of the sewer soil investigation and no radiological PCOC screening levels were exceeded.

**Inaccessible Soil Area Northwest of the 50-series Excavation Area:** Three soil samples (i.e., HTZ134481, HTZ134482, and HTZ134483) were collected in an area adjacent to the original 50-series excavation. The samples were collected at approximately 4 to 6 ft bgs during support of utility work. The subsurface soils in this area are inaccessible due to utilities. The calculated $SOR_N$ values for HTZ134481, HTZ134482, and HTZ134483 are 1.93, 4.85, and 7.98, respectively.

**Southeastern Corner of Plant 2:** Three soil sampling locations (i.e., SLD125417, SLD125421, and SLD125425) were sampled east of the accessible soil remediation area at the southeastern corner of Plant 2. SLD125417 and SLD125421 were adjacent to the RR spur and SLD125425 was near a small shack as shown on Figure C-2. The radiological sample results presented in Table E-2 show that the $SOR_N$ value for location SLD125425 was 1.15 in the deepest soil sample interval collected at 5.5 ft. Auger refusal was encountered at this depth. SLD125421 was analyzed for metal PCOCs and concentrations are less than the metal screening levels.

#### *4.2.2.3 Summary of Plant 2 Inaccessible Soil Results*

The inaccessible soil areas in Plant 2 that exceed the screening level include an area at Building 508, a small area south of 50-series building excavation, a small area northwest of 50-series building excavation, and an area in the southeast corner near a small unlabeled building. These areas are further evaluated in the BRA. See Figure C-2 for the inaccessible areas and samples that exceed the radiological screening level. No areas exceeded the metal screening levels; therefore, metals will not be further evaluated in the BRA for Plant 2. No other soil areas associated with buildings in Plant 2 require further evaluation.

### 4.2.3 Mallinckrodt Plant 6 and Plant 6E

Twenty-six soil samples were collected, as described in Section 2.2, from biased sampling locations, as shown on Figure C-3. The results of the RI samples, as well as existing data, were used to evaluate the extent of radiological contamination. Radiological contamination above the screening level was identified in one area located in the southwest corner of Plant 6. The following section presents a description of Plant 6, detailed sampling information on an area-by-area basis and a summary of the results. The area of detected contamination located adjacent to Hall Street, as shown on Figure C-3, is discussed in Section 4.5.2.

#### *4.2.3.1 Description of Plant 6 and Plant 6E*

Plant 6 is located in the eastern portion of the Mallinckrodt property and, historically, two Plant 6 areas were defined: Plants 6 and 6E (Figure 1-3). Plant 6 was built in 1945-1946 on a site fronting Destrehan Street. Most of the offices, laboratories, and support facilities for the uranium refining operations for MED/AEC activities were moved there from Plants 1 and 2. All the buildings once used as MED/AEC processing facilities have since been demolished. Currently, three buildings are present at Plant 6 including Building 100, Building 101 and Building 103. There is a RR spur northwest of Building 101 (Figure C-3).

Uranium metal production operations from Plant 10 were moved to Plant 6 (Figure 1-3). None of the buildings that were used by MED/AEC remain at Plant 6. Plant 6E borders Plant 6 on the east. The existing buildings at Plant 6E include 120, 121, 122, 123, 125, 130, and 131. These buildings were built in the 1980s and were used by Mallinckrodt for commercial chemical manufacturing operations (Figure C-3).

Buildings 100 and 101, in Plant 6, were both built after MED/AEC operations. The construction method used for Building 100 allowed for soil remediation beneath the building as part of the accessible soil remedial action and therefore, requires no further evaluation as part of this RI. Building 101 is scheduled for demolition, and any soil remaining within the footprint of Building 101 is considered accessible soil and therefore, is outside the scope of this RI. Building 103 was recently constructed after accessible soil remediation. The RR spur was removed and replaced during accessible soil remediation. Any MED/AEC sewers located near or beneath these buildings were evaluated as part of this RI and are discussed in Section 4.7.4. An area in the southwest corner of Plant 6 could not be completely remediated due to utilities. RI characterization activities were conducted in the southwest corner of Plant 6 adjacent to Destrehan Street.

In Plant 6E accessible soil remediation was not performed adjacent to Buildings 120, 121, 122, 125, 130, and 131. Therefore, the inaccessible soil beneath Buildings 120, 121, 122, 125, 130, and 131 is classified as non-impacted. Accessible soil remediation was conducted adjacent to Building 123 in Plant 6E. Therefore, the inaccessible soil adjacent to the previous remediation, beneath Building 123, was considered impacted. Any MED/AEC sewers located near or beneath these buildings were evaluated as part of this RI and are discussed in Section 4.7.4. RI characterization activities were conducted at Building 123.

#### *4.2.3.2 Nature and Extent of Contamination at Plant 6 and Plant 6E*

This section presents the results of the RI sampling of inaccessible soil areas at Plant 6.

Plant 6 is defined as being within the uranium-ore processing area, and therefore, soil samples collected for the evaluation at Plant 6 were analyzed for both radiological and metal PCOCs.

Inaccessible soil samples were collected from systematic, random, and biased sampling locations at Plant 6 and Plant 6E as shown on Figure C-3. A summary of the radiological data from Plant 6 is shown in Table 4-2. The metals data are presented in Table 4-3. The analytical results and $SOR_N$ values for each sample collected at Plant 6 during this RI are presented in Table E-4 (radiological) and Table E-5 (metals).

**Inaccessible Soil Area at Southwest Corner of Plant 6WH:** Accessible soil remediation activities at Plant 6 indicated that a small inaccessible area of detected subsurface soil contamination is located in the southwestern corner of Plant 6 adjacent to Destrehan Street. Remediation could not continue in this area due to utilities. Three surface samples (SLD110019, HTZ108618, and HTZ108619) were collected in this area prior to RI activities. All three sample results exceeded the radiological screening level. Two biased RI soil samples were collected in this area. SLD127552 had to be relocated to the east of the inaccessible area due to the presence of utilities. Both locations were sampled to a depth of 18 ft in accordance with the RI WP. The results identified radiological contamination above the screening level at location SLD127542 at an approximate depth of 4 ft. The $SOR_N$ value for this depth at this location was 1.29. The remaining soil samples (surface and subsurface) have $SOR_N$ values less than 1.0. The soil sample from location SLD127552 was analyzed for metal PCOCs and all concentrations were below screening levels (Table E-5).

**Inaccessible Soil Area along Destrehan Street:** The area of contamination south of Building 101 adjacent to Destrehan Street will be addressed during remediation of Destrehan Street and therefore, is outside the scope of this RI. However, the RI sample locations are shown on Figure C-3.

**Building 123:** At Plant 6E, one biased soil sample was collected beneath the Building 123 foundation to a depth of 6 ft. Data from the RI sampling location SLD127602 collected in 2010 and at SLD05005 collected in 2000 did not exceed radiological or metal PCOC screening levels. Building 123 is used by Covidien for chemical storage. The GWS was not performed based on safety concerns regarding a chemical odor inside Building 123. The soil sampling and GWS proposed for Building 123 were based on the small accessible soil remediation adjacent to the northwest corner of the Building as shown on Figure C-3. The results of the RI soil sample collected inside the building adjacent to the accessible soil remediation did not exceed radiological and metal PCOC screening levels and is sufficient to evaluate the soils beneath Building 123.

#### *4.2.3.3 Summary of Plant 6 and Plant 6E Inaccessible Soil Results*

The area in the southwest corner adjacent to Destrehan St. is the only inaccessible soil area in Plant 6 that exceeds the radiological screening level. This area is further evaluated in the BRA. See Figure C-3 for the inaccessible areas and samples that exceed the screening levels. No other soil areas associated with buildings in Plant 6 require further evaluation.

### 4.2.4 Mallinckrodt Plant 7

Five samples from one biased location were collected to assess the radiological concentrations in soil at an inaccessible area located in deep soil (>10 ft) contamination in the northeastern corner of Plant 7 (Figure C-4). However, this area is now being addressed by the 1998 ROD and is no longer within the scope of the ISOU.

#### *4.2.4.1 Description of Plant 7*

Plant 7 is located in the southeastern portion of the Mallinckrodt Plant area (Figure 1-2). Plant 7 is currently divided into four areas [7 North (7N), 7 South (7S), 7 East (7E), and 7 West (7W)], of which, two areas (7N and 7S) are within the scope of the ISOU. Historically, MED/AEC operations were primarily conducted at the Plant 7N area (Figure 1-3). Plant 7 was used by MED/AEC for conversion of $UO_3$ to $UF_4$, for uranium metal recovery, and for some storage operations. No MED/AEC buildings remain at Plant 7N, as all of the buildings used by MED/AEC operations at Plant 7 were demolished in 1997 and removed to their foundations as part of the interim actions under FUSRAP. In 2010, the Hazardous Waste Storage Area located in Plant 7N was razed. The MED/AEC-contaminated soil was removed from the area as accessible soil under the 1998 ROD.

Plant 7S (Figure C-4) was acquired by Mallinckrodt from Thomas and Proetz Lumber Company (identified as DT-10) in 1959. During demolition and decontamination of the Destrehan Street plants (Plants 6 and 7) in the 1960's, scrap material and equipment were stockpiled in open areas throughout these plants and the newly acquired Plant 7S property (Shaw 2004a). Covidien utilizes Plant 7S as a trailer drop lot with other portions being used as a parking area. Portions of Plant 7S are also used by USACE as a material laydown area for FUSRAP activities. Plant 7S contains the FUSRAP water treatment plant which is used for accessible soil remediation activities. The accessible soil beneath and surrounding this building has been remediated; therefore, no building surveys or inaccessible soil sampling were required for this RI. Plant 7W is not within the scope of the ISOU as discussed in Section 1.1.2.

#### *4.2.4.2 Nature and Extent of Contamination at Inaccessible Soil Areas at Plant 7*

One inaccessible soil area of detected contamination was identified in the northeastern corner of Plant 7N. This area remained as a result of the accessible soil remediation efforts to remove and replace most of the 30-in sewer located along the south side of Destrehan Street between February 2005 and August 2006 (Shaw 2010). The radiological analytical results for each sample collected at Plant 7 during this RI are presented in Table E-6. However, after the RI sampling was completed, it was determined that this area of contamination would be addressed under the 1998 ROD. Therefore it is now outside the scope of this RI.

#### *4.2.4.3 Summary of Plant 7 Inaccessible Soil Results*

The area of inaccessible soil as presented in the RI WP is now being addressed as accessible soil under the 1998 ROD. No inaccessible soil areas remain on Plant 7.

### 4.2.5 Mallinckrodt West Properties (Plants 3, 8, 9, and 11 and Parking Lots)

At Mallinckrodt Plant 3, eighteen soil samples were collected from several biased sampling locations at the southeast corner of Building 63. The results of the soil sampling at Building 63 indicate no radiological contamination above screening levels. Mallinckrodt Plants 8, 9, and 11, the Mallinckrodt parking lot located north of Plant 11, and the western portion of Plant 3 are defined as non-impacted and therefore were not sampled.

#### *4.2.5.1 Description of Mallinckrodt West Properties*

The Mallinckrodt West Properties include Plants 3, 8, 9, and 11 and the Mallinckrodt parking lot located north of Plant 11. These properties are located near the western and northwestern edges of the Mallinckrodt Plant area (Figure 1-2). There is no evidence or documentation of MED/AEC-related activities being conducted at Plants 3, 8, 9, and 11 or the parking lots.

Plant 3 (Figure C-5) contains eight buildings (62, 63, 63A, 65, 66, 74, 75, and 76). Buildings 62, 63, and 63A were constructed prior to the 1940s and prior to MED/AEC activities. Buildings 65, 66, 74, 75, and 76 were built after MED/AEC operations.

Plant 8 was purchased by Mallinckrodt in 1946 and was formerly the location of the dynamo house for the St. Louis Transit Company trolleys (NPS 1997). There are five structures located at Plant 8, none of which were used for MED/AEC activities (Figure C-5). DT-32, Westerheide Tobacco, was previously located on the western side of Plant 8, but the property was purchased by Mallinckrodt. The building was demolished and the area where Westerheide Tobacco once stood is now a parking lot.

Plant 9 contains Buildings 96, 98, 902, and 903 and several smaller buildings. The largest building, Building 96, covers most of the southern portion of Plant 9 (Figure C-5). The current ground surface of Plant 9 is covered with consolidated cover material consisting of asphalt and asphalt/concrete that is approximately 0.6 to 1.0 ft thick (Shaw 2006).

At Plant 11, there are currently one large building (Building 97) and two smaller structures. Much of the surface material at Plant 11 and the Mallinckrodt parking lot to the north consists of approximately 0.5 ft of asphalt (Shaw 2006).

#### *4.2.5.2 Nature and Extent of Contamination at Inaccessible Soil Areas at the Mallinckrodt West Properties*

This section presents the results of the RI sampling of inaccessible soil areas at the Mallinckrodt West Properties.

The Mallinckrodt West Properties are not located within the uranium-ore processing area of the historic MED/AEC plant areas and, therefore, only radiological PCOCs are evaluated for inaccessible soil.

Inaccessible soil locations at the Mallinckrodt West Properties are shown on Figure C-5. A summary of the radiological data from the Mallinckrodt West Properties is presented in Table 4-2. The analytical results and $SOR_N$ values for each sample collected at Plant 2 during this RI are presented in Table E-7.

No sampling for inaccessible soil was proposed for Plants 8, 9, 11, and Mallinckrodt Parking Lot, and the western portion of Plant 3. During accessible soil investigations, a surface soil sample (HTR84770) was collected in the southeastern corner of Building 63 in 2005 which had an $SOR_N$ value of 1.11. Additional samples were collected at this corner during FSS activities for the Mallinckrodt West Properties. The result of the FSS evaluation concluded that this area complies with the areal average stated in the ARAR-based RG (USACE 2006). No accessible soil remediation was conducted. The inaccessible soil beneath Building 63 is unlikely impacted, but data was collected from beneath the foundation inside the building and adjacent to the foundation to ensure that radiological contamination detected at that location did not extend beneath the building.

Twelve soil samples were collected in the southeastern corner of Building 63 at Plant 3 from biased sampling locations. Sample location SLD125303 was one of the two proposed biased samples that was collected inside of Building 63. The GWS and second proposed biased location were not taken because of the presence of materials inside Building 63. Soil samples from SLD125906 were also taken just outside of Building 63 as part of the investigation of Destrehan Street. The results of these samples, as well as existing data, did not identify radiological contamination above the screening level.

The results of the soil sampling at Building 63 indicate no radiological contamination above the screening level. Additionally, samples SLD125902 and SLD125906, collected from Destrehan Street nearby Building 63, did not exceed the radiological screening level.

#### *4.2.5.3 Summary of Mallinckrodt West Properties Inaccessible Soil Results*

Mallinckrodt Plants 8, 9, and 11, the Mallinckrodt parking lot located north of Plant 11, and the western portion of Plant 3 are defined as non-impacted. The results of the soil sampling at Building 63 at Plant 3 indicate no radiological contamination above the screening level. Therefore, no risk evaluation of the Mallinckrodt West Properties is conducted in the BRA.

### 4.2.6 Mallinckrodt Security Gate 49 Area

Sixteen soil samples were collected from systematic and biased sampling locations in inaccessible soil areas at the guard shack and a portion of North Second Street that lie within the Security Gate 49 area (Figure C-6). The results for the inaccessible soil show that no samples exceeded the radiological screening level.

#### *4.2.6.1 Description of Gate 49 Area*

The Mallinckrodt Security Gate 49 area is a triangular-shaped tract of land located in the southwestern portion of the Mallinckrodt property at the intersection of North Second Street and Angelrodt Street (Figure C-6). The property has a frontage of approximately 60 ft east to west along Angelrodt Street and a frontage of approximately 250 ft north to south along Plant 10. The Mallinckrodt Security Gate 49 area overlies an area that was previously the main line RR bed of the Norfolk Southern RR (DT-3) until 1954. Most of the Security Gate 49 area property consists of asphalt cover over North Second Street and a small building serves as a guard shack, which was built after MED/AEC operations.

#### *4.2.6.2 Nature and Extent of Contamination at Inaccessible Soil Areas at the Mallinckrodt Security Gate 49 Area*

This section presents the results of the RI sampling of inaccessible soil areas at the Mallinckrodt Security Gate 49 area.

The Mallinckrodt Security Gate 49 area is not within the defined uranium-ore processing area and therefore, only radiological PCOCs are evaluated.

Inaccessible soil samples were collected from two sampling locations (SLD125261 and SLD125265). Because this area is also associated with North Second Street, two systematic soil samples (SLD126193 and SLD126197) also were collected in this area as part of the roadway characterization as shown on Figure C-6. The GWS results for the North Second Street inaccessible soil area are presented on Figure D-12 as part of the discussion for roadway vicinity properties in Section 4.5. The GWS indicated a small area of elevated radioactivity. HTZ94861 and SLD126193 represent the area of elevated radioactivity identified by the GWS. Previously collected sample HTZ94862 was also used to characterize inaccessible soil at the Security Gate 49 area.

The results of the RI samples, as well as existing data, did not identify radiological contamination above the screening level. A summary of the radiological data is shown in Table 4-2 and the analytical results and $SOR_N$ values for each sample location are presented in Table E-8. The radiological results for the inaccessible soil at the Security Gate 49 area show that no samples exceeded the radiological screening level.

#### *4.2.6.3 Summary of Gate 49 Area Inaccessible Soil Results*

No inaccessible soil samples exceeded the radiological screening level. Therefore, no risk evaluation is conducted in the BRA for the Mallinckrodt Security Gate 49 Area.

### 4.2.7 Gunther Salt Vicinity Property (DT-4)

At Gunther Salt (DT-4), one hundred and fifty-two soil samples were collected from systematic and biased sampling locations at the Administration Building/Warehouse, salt domes, storage buildings, RR spur, and at locations along Buchanan Street (Figure C-7). Radiological contamination above the screening level was identified in inaccessible soil areas on the northwest side and south side of the Administration/Warehouse Building, south of the loading dock along Buchanan Street, beneath the two salt domes, and in two areas beneath the southern storage building.

#### *4.2.7.1 Description of DT-4*

Gunther Salt (DT-4) currently operates a salt packaging and storage facility on two separate parcels (Gunther Salt North and Gunther Salt South) located diagonally across from one another in the southeast portion of the SLDS (Figure 1-2). The Gunther Salt properties were not originally included within the boundaries of the SLDS as defined in the 1998 ROD (USACE 1998a). There is no evidence or documentation of MED/AEC-related activities at Gunther Salt North or South. The evaluation of existing data for Gunter Salt South determined that the inaccessible soil and building at the property are non-impacted (USACE 2009a).

Gunther Salt North is an approximately 3.5-acre property located northwest of the intersection of Hall and Buchanan Streets (Figure C-7). The 1909 and 1950 Sanborn Maps show that the North property was used as a lumber yard with lumber storage on the undeveloped portion of the property. Gunther Salt purchased the site in 1984. Gunther Salt (DT-4) North is occupied by five buildings: two roughly rectangular storage buildings on the western edge of the property; two circular salt storage domes in the middle of the property; and one large brick Administration/Warehouse Building on the eastern half of the property that houses an office, packaging equipment, and packaged salt storage (Figure C-7). The buildings and salt domes at Gunther Salt (DT-4) North were constructed after initiation of MED/AEC activities at the Mallinckrodt facility (i.e., post 1941). The three buildings at the Gunther Salt (DT-4) North property were constructed during the period between 1951 and 1953, and the two salt domes were constructed between 1986 and 1994 (USACE 2005c). Reconfiguration of the large building at the Gunther Salt (DT-4) North property occurred periodically after 1951, with the latest modification completed by 1988. Most of the property currently at Gunther Salt (DT-4) North is covered by buildings or asphalt pavement except for the area covered with gravel in the southwestern portion of the property between the southern salt dome and southern rectangular storage building. The floors of the rectangular storage buildings are earthen. A RR spur from DT-9 enters the property along the eastern boundary and was constructed prior to 1951.

#### *4.2.7.2 Nature and Extent of Contamination at DT-4*

This section presents the results of the RI sampling of inaccessible soil areas at Gunther Salt (DT-4) North.

DT-4 is not located within the defined uranium-ore processing area and therefore, only radiological PCOCs are evaluated.

Inaccessible soil areas at Gunther Salt (DT-4) North include the soil beneath and adjacent to the five buildings and the RR spur located at the property. Additionally, five areas (north of the Administration/Warehouse Building, along the Buchanan Street sidewalk, the area outside the two salt domes, and at the northeastern corner of the Southern Storage Building) were identified as inaccessible areas of detected contamination remaining from accessible soil remediation activities at the property (Figure C-7). Because the salt dome structures did not have a subsurface foundation, a 3-ft buffer around the base of the domes was established where excavation was not allowed because excavation closer to the domes would potentially undermine the structure.

Inaccessible soil samples were collected from systematic and biased sampling locations as shown on Figure C-7. The GWS results for each inaccessible soil area are presented on Figures D-3-1 through D-3-4. The results of these samples, as well as existing data, were used to evaluate the extent of soil exceeding the radiological screening level. A summary of the RI data is shown in Table 4-2 and the radiological data and $SOR_N$ values for each sample location are presented in Table E-9.

**Administration/Warehouse Building:** At the Administration/Warehouse Building, biased soil samples were collected inside the building in areas that were adjacent to accessible soil remediation areas. Five soil samples were collected in the northern portion of the building and five biased samples were collected near the loading dock in the southern end of the building. Soil samples also were collected at several locations in these two areas during previous investigations. Soil was also sampled at 10 systematic locations.

The results indicate that soil in the northwestern corner, west-central, and southern end of the building near the loading dock is above screening levels. One area defined as an inaccessible area of detected contamination is on the northern edge of the Administration/Warehouse Building near the accessible soil remediation area conducted in the northern portion of the property. In the northwestern corner, RI samples collected from location SLD125065 at a depth of 2.5 to 3.0 ft resulted in an $SOR_N$ value of 1.11. Samples collected in 2007 in this area as part of accessible soils remediation activities (SLD103236, SLD103238, SLD103235, SLD103112, and SLD103113) had $SOR_N$ values ranging between 2.15 and 12.71. In the west-central area, the soil sample collected at a depth of 1.5 to 2.0 ft at location SLD125085 had an $SOR_N$ value of 3.12. In the southern portion of the building near the loading dock, three locations (SLD125093, SLD125101, and SLD125105) sampled during the RI exceeded the radiological screening level in samples collected in depths ranging between 0 and 3 ft below cover material. The $SOR_N$ values at these locations ranged between 1.66 and 2.86. These results are consistent with previous samples collected in this area (i.e., SLD96771 and SLD96775). No additional samples were collected based on GWS results.

**Salt Domes:** As shown on Figure C-7, radiologically contaminated soil is present at areas surrounding the two salt domes on this property. Accessible soil remediation was conducted adjacent to the domes, and the area just outside and surrounding the domes was identified as an inaccessible area of detected contamination. Many inaccessible soil samples were previously collected outside the domes as part of the accessible soil remediation activities and the $SOR_N$ values exceeded the screening level to depths between 1 and 4 ft.

Biased and systematic soil sampling locations were planned for this RI to evaluate whether radiological soil contamination extended beneath the salt domes. Two of the proposed locations for the RI sampling at the salt domes could not be collected due to safety concerns created by the presence of salt piles as part of the operational use of the property by Gunther Salt. Both of the samples collected (SLD125033 and SLD125049) indicated that radiological contamination exceeding the screening level is present beneath the domes to depths of 1 to 3 ft. The highest $SOR_N$ value for these locations was 18.2 at a depth of 1.5 to 2.0 ft at SLD125049. The $SOR_N$ values at the previously sampled locations at the salt domes ranged between 1.09 and 74. The GWS was conducted at the domes but limited areas could be accessed because of the presence of salt piles (Figure D-3-2). The GWS did not indicate areas that warranted additional sampling.

**Storage Buildings:** Soil samples were collected from systematic sample locations at the two storage buildings on the west side of the property. Additionally, three biased soil sample locations were collected at the southern storage building adjacent to the accessible soil remediation area. A

GWS was conducted at both buildings (Figures D-3-3 and D-3-4) and two additional sample locations (SLD130237 and SLD130239) were sampled at the southern storage building.

The results of the RI sampling at two locations (SLD124977 and SLD124981) at the northern storage building show that no samples exceeded the radiological screening level.

At the southern storage building, the results of biased soil sampling show that radiological contamination exceeding the screening level does not extend into the southern storage building at the northeastern corner adjacent to the accessible soil remediation area. Just outside the building, a small area was previously defined as an inaccessible area of detected contamination based on results from four sampling locations (SLD104915, SLD104916, SLD104922, and SLD104923). Samples were collected at these locations at a depth of 2 to 3 ft and the $SOR_N$ values ranged between 1.23 and 102.

The systematic soil sampling conducted at the southern storage building identified an area of elevated radiological contamination at the southwestern end of the building. A GWS was conducted and, based on the results, the systematic sample proposed for this portion of the storage building was moved to the west to the location with the highest radioactivity. Two soil sample results from this location (SLD125005) had $SOR_N$ values of 6.5 and 1.41 at a depth of 1.0 to 2.5 ft. Additional samples were collected at SLD130237 and SLD130239 to a depth of 1 ft to evaluate the lateral extent of contamination. These samples also exceeded the screening level, with $SOR_N$ values ranging between 1.97 and 27.6. Samples collected in 2001 west of this area at HTZ27440 did not exceed the screening level.

**Buchanan Street Sidewalk at DT-4 North:** One area defined as an inaccessible area of detected contamination is located between the loading dock of the Administration/Warehouse Building and Buchanan Street. Sampling was conducted to the east along the sidewalk after remediation of the loading dock area and indicating that additional areas (SLD105098 and SLD105101) to the east of the loading dock were radiologically contaminated. Due to utilities this area was defined as inaccessible.

Three RI soil sample locations (SLD125137, SLD125169, and SLD125173), as shown on Figure C-7, were collected to the east of the excavation under the sidewalk to the southeast corner of the property to evaluate the lateral extent of contamination. At location SLD125137, samples were collected beneath the sidewall of the excavation to a depth of 7.5 ft below the surface. Two soil sample results from this location (SLD125138 and SLD125139) had $SOR_N$ values of approximately 7.6 and 2.5 at a depth of 3.0 to 4.0 ft, respectively. Samples from locations SLD125169 and SLD125173 did not exceed the screening level. The lateral extent of contamination of this inaccessible area is smaller than originally defined and occurs just east of the loading dock (Figure C-7).

Additional sampling of soil beneath Buchanan Street also was conducted as part of the ISOU roadways evaluation adjacent to an excavation area and sidewalk at DT-4 and is presented in Section 4.5.8.

**RR Spur:** Several biased soil samples were collected from the RR track in the northeastern portion of DT-4. Data from the inaccessible soil beneath the RR spur located at Gunther Salt North show that the screening level was not exceeded for the radiological PCOCs.

#### *4.2.7.3 Summary of DT-4 Inaccessible Soil Results*

The evaluation of existing data for Gunther Salt (DT-4) South indicated that the inaccessible soils at the property are non-impacted.

At Gunther Salt (DT-4) North, radiological contamination above the screening level was identified in inaccessible soil areas associated with the Administration/Warehouse Building, along Buchanan Street, at two salt domes, and the southern storage building. These areas are evaluated in the BRA. See Figure C-7 for the inaccessible areas and samples that exceed the radiological screening level. No other soil areas associated with buildings at DT-4 require further evaluation.

### 4.2.8 Heintz Steel and Manufacturing Vicinity Property (DT-6)

One hundred and six inaccessible soil samples were collected from systematic, random, and biased sampling locations at the Fabrication Building, the Storage Building, and the AT&T Complex as shown on Figure C-8. Radiological contamination above the screening level was identified in inaccessible soil at the Storage Building.

#### *4.2.8.1 Description of DT-6*

The Heintz Steel and Manufacturing VP (DT-6) is located at 3300 Hall Street and is south of the Mallinckrodt Plant area (Figure 1-2). The property is currently being used for the manufacturing and fabrication of steel products. DT-6 is located approximately 800 ft south of the former Mallinckrodt Plant 6 property, which was involved in MED/AEC activities in the 1940s and 1950s, but there is no evidence or documentation of MED/AEC-related activities at DT-6.

Three buildings (Fabrication Building, Storage Building, and the AT&T Complex) are located at the property (Figure C-8). The current, basic property configuration was established between 1973 and 1974, although a large structure in the northwest corner of DT-6 appears to have been present at the property in 1952.

#### *4.2.8.2 Nature and Extent of Contamination at DT-6*

DT-6 is not within the defined uranium-ore processing area; therefore, only radiological PCOCs are evaluated for DT-6.

Inaccessible soil samples were collected from systematic, random, and biased sampling locations associated with the three buildings at the property: Fabrication Building, Storage Building, and the AT&T Complex as shown on Figure C-8. A GWS was conducted at the Fabrication Building and the results are presented on Figure D-4. The results of these samples, as well as existing data, were used to evaluate the extent of radiological contamination. A summary of the RI data is shown in Table 4-2 and the analytical results for each sample location at DT-6 and the calculations of $SOR_N$ values are presented in Table E-10.

**Fabrication Building:** Soil was collected from several systematic sampling locations to a depth of 6 ft as proposed in the RI WP. A GWS was also conducted, which resulted in two additional samples (SLD123730 and SLD123734) collected from beneath the eastern portion of the building. The results showed that the radiological concentrations in soil beneath the Fabrication Building are not above the screening level.

**Storage Building:** Several biased and two systematic sampling locations were collected at the Storage Building in accordance with the RI WP. Biased soil samples were collected adjacent to soil areas to the east and south of the Storage Building adjacent to areas remediated as part of the accessible soil remediation.

Because the Storage Building has a dirt floor, a GWS and soil samples were collected as part of accessible soil remediation activities at DT-6. The results showed radiological $SOR_N$ values greater than 1.0 to a depth of 2.5 ft inside the structure. Accessible soil remediation activities were conducted inside the Storage Building. Excavation activities proceeded until no additional soil could be removed due to structural stability issues and the presence of concrete foundation piers. Several additional samples were collected inside the building. The results indicated that radiological contamination is still present to a depth of 3.5 ft in the northeast corner of the building (SLD122786, SLD122790, and SLD123198) and to the south (HTZ75371).

The soil west of the Storage Building (i.e., beneath Hall Street) was defined as an inaccessible area of detected contamination. Screening samples (prefix HSM) also were collected in 2003 along the west side of the excavation and the resulting $SOR_N$ values ranged between 1 and 7.56 at locations HSM00281, HSM00287, HSM00298, HSM00301, and HSM01052 to a depth of 4 ft. RI samples collected in October of 2009 at locations SLD120993 and SLD120997 to a depth of 6 ft had $SOR_N$ values less than 1.0.

**AT&T Complex:** The AT&T Transmission Building and associated tower are located in the northeastern corner of DT-6. Soil samples from two locations (one biased and one random) within the footprint of the building were collected. A GWS was not conducted at the AT&T Complex due to limited access inside the building. The results showed that the radiological concentrations in soil beneath the AT&T Complex are not above the screening level.

#### *4.2.8.3 Summary of DT-6 Inaccessible Soil Results*

Inaccessible soils at the Fabrication Building and the AT&T Complex did not exceed radiological screening level. Radiological contamination above the screening level was identified in inaccessible soil at the Storage Building in the northeastern corner and along the western edge of the building along Hall Street. These areas are evaluated further in the BRA. See Figure C-8 for the inaccessible areas and samples that exceed the radiological screening level. No other soil areas associated with buildings at DT-6 require further evaluation.

### 4.2.9 PSC Metals, Inc. Vicinity Property (DT-8)

Two hundred and ninety-seven inaccessible soil samples were collected, as described in Section 2.2, from systematic, random, and biased sampling locations at North Tracts 1, 2, 3, and 4 and the South Tract as shown on Figure C-9. Radiological contamination above the screening level was identified in inaccessible soil in an area of the RR tracks in North Tract 3, North Tract 4, and in the southeast corner of Warehouse located in the South Tract.

#### *4.2.9.1 Description of DT-8*

PSC Metals, Inc. (DT-8) is a large VP located in the northeastern portion of the SLDS and is approximately 17.6 acres in size. The property consists of several parcels of land both north and south of the McKinley Bridge. PSC Metals, Inc., currently purchases, segregates, and processes all types and grades of industrial, dealer, and retail ferrous and non-ferrous scrap metal. Available information indicates that DT-8 was not used for MED/AEC-related activities. For discussion purposes, the parcels have been identified as "tracts," as shown on Figure C-9.

North Tract 1 is located at the northwestern corner of the SLDS, bound by Bremen Avenue on the north and North Second Street on the west. Three buildings, designated as Buildings A, B, and C, are located on North Tract 1. Building B, Building C, and the RR spur located on North Tract 1 was addressed as accessible soil under the 1998 ROD.

North Tract 2 is located east of North Tract 1, south of Bremen Avenue, and west of the BNSF RR (DT-12). Several buildings and structures are located in this tract of DT-8, including a Scale House, Building D, various support structures, and the RR tracks used to support DT-8 operation.

North Tract 3 is located south of North Tract 2. North Tract 3 has three trailers located along the western boundary and several RR tracks.

North Tract 4 is located south of North Tract 3 and is bound on the south and west by the Illinois Department of Transportation and the Missouri Department of Transportation VP (DT-11). One building (E) is located at this property and it encompasses most of the area of land within this tract. Several RR tracks are located in the western portion on North Tract 3.

The South Tract property of DT-8 is located south of the McKinley Bridge and the southern boundary of DT-8 is adjacent to the Mallinckrodt Plant 6 area. Three buildings, including the Administration/Warehouse Building, smelter house, and a small support building (F), are located within the South Tract. Several RR spurs are located on the South Track. As shown by the soil excavation boundary (Figure C-9), soil beneath some rail spurs was excavated as part of the accessible soil remediation activities; soil beneath the remaining spurs is considered inaccessible.

The remaining portions of DT-8 (East Tract 1 and East Tract 2) are undeveloped areas located near the McKinley Bridge, east of the BNSF RR (DT-12) and west of the Mississippi River levee. No buildings, structures, or inaccessible soil remain at East Tracts 1 or 2 of DT-8.

Inaccessible soils associated with several areas at DT-8 were defined as non-impacted in the RI WP. Building A in North Tract 1 was built prior to MED/AEC activities and did not have accessible soil remediation adjacent to it. On North Tract 1, Buildings B and C have dirt floors and were evaluated as part of the accessible soil remediation activities. The small support structures on North Tract 2 did not have accessible soil remediation adjacent to the buildings. The three trailers on North Tract 3 are not defined as permanent structures and, therefore, were addressed with accessible soil.

MED/AEC sewers located near or beneath these buildings and RR tracks were evaluated as part of this RI and are discussed in Section 4.7.7.

#### *4.2.9.2 Nature and Extent of Contamination at DT-8*

This section presents the results of the RI sampling of inaccessible soil areas at DT-8.

DT-8 was not considered a uranium-ore processing area, and therefore, the soil sample data evaluation included only radiological PCOCs.

Inaccessible soil samples were collected from systematic, random, and biased sampling locations at DT-8 as shown on Figure C-9. The GWSs conducted at the buildings proposed for soil sampling are presented on Figure D-5-1 through D-5-6. A summary of the radiological data from DT-8 is shown in Table 4-2. The analytical results and $SOR_N$ values for each sample collected at DT-8 during this RI are presented in Table E-11.

RI characterization activities were conducted at the Scale House, Building D, Building E, the Smelter Building, the Administration Building, the Warehouse and the RR Tracks on North Tracts 2, 3, 4 and the South Tract. Inaccessible soil associated with the North Tract 1 building (Building A) was defined as non-impacted (USACE 2009a).

**North Tracts 2, 3, and 4:** Random soil samples were collected at three locations beneath the Scale House. Biased soil samples were collected at one location near Building D and at two locations along the RR tracks (at North Tract 3) where historic sampling results from accessible soil investigations had $SOR_N$ values greater than 1.0. Additionally, soil samples were collected at random sampling locations at the remaining buildings of North Tracts 2, 3, and 4 and on the RR tracks in accordance with the RI WP. GWSs were conducted at Buildings D and E, the Scale

House, and RR tracks (Figures D-5-1 through D-5-3 and D-5-6). The GWSs did not identify areas warranting additional soil samples.

The analytical results show that samples collected from North Tract 2 inaccessible soil areas do not exceed the screening level for radiological PCOCs.

At North Tract 3, two biased samples (SLD123572 and SLD123560) were collected in inaccessible soil areas beneath the RR tracks and adjacent to areas where prior accessible soil sampling found elevated soil concentrations. The $SOR_N$ values were less than 1.0, thus indicating that radiological contamination does not exceed the screening level beneath the RR tracks. Soil sampling at several random locations along the RR tracks also was conducted. One location (SLD123584) along the RR tracks had an $SOR_N$ value of 1.63 at a depth of 0 to 0.5 ft, which exceeds the screening level (Table E-11).

At North Tract 4, one biased sample (SLD69763) was collected along the RR tracks an $SOR_N$ value of 1.04 at a depth of 0 to 0.5 ft, which exceeds the screening level (Table E-11). All other radiological results from soil sampling locations along the RR showed concentrations below the screening level. Additionally, the radiological results from soil sampling beneath Building E were below screening level.

**South Tract:** Systematic, random, and biased soil samples were collected in several inaccessible soil areas as part of this RI to evaluate the extent of potential contamination beneath the Administration/Warehouse Building, Smelter House, and RR tracks. A GWS was conducted within the footprint of the buildings and RR track (Figures D-5-4 through D-5-6) and did not identify areas warranting additional soil samples.

The results of the RI sampling at the South Tract indicate that radiological contamination just above the screening level was detected at one location (SLD123696) in the southeastern corner of the Warehouse. The sample collected between 2.0 and 2.5 ft had an $SOR_N$ value of 1.02. The remaining locations sampled in other areas of the building did not exceed the screening level.

The soil sample collected at the smelter house (SLD123676) was collected inside the building. The $SOR_N$ values were less than 1.0 at the depths sampled to 3.5 ft.

The inaccessible soil areas associated with the RR tracks were sampled at both random and biased locations because several inaccessible soil excavation areas were adjacent to or within the RR tracks or ROW. At the South Tract, some portions of the RR north of the Plant 6 boundary were remediated. The RI sampling results at several locations indicated that no additional areas of radiological contamination exceeding the screening level are present along the RR in the South Tract at DT-8.

Two sample locations proposed in the RI WP were changed during field sampling at the South Tract. Sample SLD123592 was moved from outside the Administration Building to inside the northeast corner of the building due to the presence of utilities. SLD123680 was moved outside the Administration Building due to accessibility issues inside the building.

#### *4.2.9.3 Summary of DT-8 Inaccessible Soil Results*

Inaccessible soil areas at DT-8 that exceeded the screening level included an area of the RR tracks in North Tract 3, North Tract 4, and an area in the southeast corner of the Warehouse located in the South Tract. These areas are further evaluated in the BRA. See Figure C-9 for the inaccessible samples that exceeded the screening level. No other soil areas associated with buildings at DT-8 require further evaluation.

### 4.2.10 Thomas and Proetz Lumber Company Vicinity Property (DT-10)

Forty-six inaccessible soil samples were included in the RI evaluation from random and biased sampling locations at the Dry Kiln and the Office Building as shown on Figure C-10. The inaccessible radiological soil sample results at DT-10 indicated that the radiological screening level was not exceeded. Metal PCOCs were analyzed in samples collected at eight locations at DT-10. Arsenic was detected above the screening level [60 milligrams per kilogram (mg/kg)] in three DT-10 soil samples collected within the footprint of Office Building (Figure C-10).

#### *4.2.10.1 Description of DT-10*

The Thomas and Proetz Lumber Company VP (DT-10) is an approximately 2.6-acre property located at 3400 Hall Street and south of Mallinckrodt Plant 7 (Figure 1-2). The Thomas and Proetz Lumber Company has operated a lumber yard at this location since the early 1900s. Several large lumber storage sheds, a drying kiln, a Saw Building, a Planer Building, and a brick office building occupy the property (Figure C-10). The property is fenced on all four sides and the ground surface is covered predominately by gravel and asphalt. A RR spur enters the property from the southwest corner and terminates by the Planar Building.

Available information indicates that DT-10 was not used for MED/AEC-related activities. The only buildings that were constructed prior to MED/AEC processing operations are the brick Office Building and the Wooden Storage Building located on the southern boundary. Accessible soil remediation was conducted adjacent to the Office Building and the Dry Kiln. Therefore, the inaccessible soil beneath the Office Building and the Dry Kiln is classified as impacted. The floors of the remaining buildings are dirt or gravel and were addressed as accessible soil under the 1998 ROD. The RR spur was also addressed during accessible soil remediation on DT-10. See Section 4.2.5 of the RI WP for more details. RI characterization activities were conducted at the Dry Kiln and the Office Building.

#### *4.2.10.2 Nature and Extent of Contamination at DT-10*

This section presents the results of the RI sampling of inaccessible soil areas at DT-10.

DT-10 was defined as being within the uranium-ore processing area due to the proximity of this VP to Plant 7; therefore, both radiological and metal PCOCs are evaluated.

Inaccessible soil samples were collected from random and biased sampling locations at DT-10 as shown on Figure C-10. The GWSs conducted within the footprint of the Office Building and the Dry Kiln as presented in Figures D-6-1 and D-6-2, respectively. No additional soil samples were collected based on the survey results. A summary of the radiological data from DT-10 is shown in Table 4-2. A summary of the metals data are presented in Table 4-3.The analytical results and $SOR_N$ values for each sample collected at DT-10 during this RI are presented in Table E-12 (radiological) and Table E-13 (metals).

Soil samples were collected at each location to a depth of 6 ft at both the Office Building and the Dry Kiln. The RI sampling showed that there were no radiological concentrations above the screening level.

The results of the metals sampling showed that there were three soil samples collected from the footprint of the Office Building that exceeded the screening level for arsenic (60 mg/kg) at the 0.5- to 1.0-ft interval (the only interval sampled). SLD120280 on the northeastern corner of the office building has an arsenic result of 85.6 mg/kg; SLD120307 and SLD120311 collected on the southern side of the building have arsenic results of 178 and 85 mg/kg, respectively. Arsenic was not detected above the screening level in the soil samples collected from the footprint of the Dry Kiln building. Additionally, cadmium and uranium concentrations at all eight locations sampled at the Office Building and Dry Kiln were below screening levels.

#### *4.2.10.3 Summary of DT-10 Inaccessible Soil Results*

The RI evaluation of inaccessible soil areas for MED/AEC- related constituents did not indicate any areas that exceeded the radiological PCOCs. Arsenic was detected in three inaccessible soil samples collected adjacent to the Office Building at DT-10 and is further evaluated in the BRA. See Figure C-10 for the inaccessible samples that exceeded the screening levels. No other soil areas associated with buildings at DT-10 require further evaluation.

## 4.3 INACCESSIBLE SOILS ASSOCIATED WITH THE LEVEE

On the eastern boundary of the SLDS, the Mississippi River levee is present and provides protection to the city of St. Louis against flooding. Construction of levee was initiated sometime between 1958 and 1962 (based on aerial photographs) and completed in 1964 (USACE 1941 – 1995). It is predominantly an earthen levee with a concrete floodwall located beneath the McKinley Bridge. The St. Louis Riverfront Trail is oriented in a north-to-south direction along the levee and is used for biking and pedestrian recreational activities. It was first opened to the public in 1999. The VPs that comprise the levee as part of the SLDS are the St. Louis City Property (DT-2) and MSD Lift Station (DT-15) (Figure 1-2). A small portion of the levee within SLDS is identified as part of the Terminal RR (DT-9) and discussed in Section 4.4.2.

### 4.3.1 St. Louis City Vicinity Property (DT-2)

Two hundred and thirty-eight samples were collected from random and biased locations at the levee area at DT-2. Samples were collected from three depths: the above ground portion of the levee, the clay-compacted area below the levee, and the deep soils approximately 25 ft bgs or greater below the base of the levee and identified as the depth of original soil prior to construction of the levee. At two biased sampling locations in the southern portion and one sample location in the central portion of DT-2 (Figure C-11), the radiological concentrations detected exceeded the screening level.

#### *4.3.1.1 Description of DT-2*

DT-2 is located east of the Mallinckrodt Plant area between the BNSF RR (DT-12) and the Mississippi River (Figure 1-2). Based on historical information, no MED/AEC work was conducted at DT-2. No buildings, roads, or RRs are present at DT-2.

DT-2 consists of undeveloped riverfront property, the Mississippi River levee, and a recreational hiking and biking trail called the St. Louis Riverfront Trail (Figure C-11). The Mississippi River levee runs along the western edge of DT-2 and provides protection to the city of St. Louis against Mississippi River flooding.

Remediation of accessible soil areas at DT-2 has been conducted since 1991 at the property, beginning with interim actions associated with the construction of the St. Louis Riverfront Trail, and most recently as part of remediation activities conducted under the 1998 ROD to address a sewer line that runs along Destrehan Street across DT-2 to the Mississippi River. The specific accessible soil areas remediated at DT-2 are shown in Figure C-11.

The only inaccessible soil area that is currently defined at DT-2 is beneath the Mississippi River levee. The levee is present at all three portions of DT-2, but the levee in the northern portion (north of the McKinley Bridge) is only slightly within the boundaries of DT-2.

#### *4.3.1.2 Nature and Extent of Contamination at DT-2*

This section presents the results of the RI sampling of inaccessible soil areas at DT-2.

DT-2 is not located within the uranium-ore processing area; therefore, only the radiological PCOCs are applicable to the inaccessible soil at this property.

Inaccessible soil samples were collected from random sampling locations and at biased sampling locations near accessible soil remediation areas as shown on Figure C-11. Additionally, soil samples were collected from three general depths based upon their historic placement: the above ground portion of the levee, the below ground base of the levee, and deep floodplain or fill soils approximately 25 ft bgs or greater below the base of the levee. A GWS was previously conducted at the property, as shown on Figure D-7. No additional soil sampling locations were identified from the GWS. A summary of the RI sampling results and results from prior characterizations of inaccessible soil at the levee is shown in Table 4-2 and the analytical results and $SOR_N$ values for each sample location are presented in Table E-14.

The results of the random soil sampling did not indicate any inaccessible soil areas with radiological concentrations above the screening level. Soil borings conducted at the random sampling locations were completed at most locations to a depth of 50 ft bgs. The soil boring logs show the presence of levee fill over urban fill (sand, coarse gravel, bricks, and slag).

Biased soil sampling was conducted, during RI activities, at central and southern portions of DT-2 adjacent to accessible soil remediation areas as shown on Figure C-11. At two locations (SLD120384 and SLD120376) in the southern portion of DT-2, the radiological concentrations detected exceeded the screening level. At SLD120384, the soil sample collected from the 4.5- to 5.0-ft interval resulted in an $SOR_N$ value of 4.31. The $SOR_N$ value was attributable to the Ra-226 concentration of 66.4 pCi/g in the sample. At soil sampling location SLD120376, the calculated $SOR_N$ was 1.86 in a sample collected at a depth of 7.5 to 8.0 ft. In this sample, Ra-226 was 28.0 pCi/g and Th-230 was 9.52 pCi/g (Table E-14).

During accessible soils remediation adjacent to the levee, biased soil sample HTR79104 was collected in an inaccessible area as shown Figure C-11. HTR79104 was collected from a depth of 3.0 to 3.5 ft and has an $SOR_N$ value of 1.41. The $SOR_N$ value was attributable to the Ra-226 concentration of 21.7 pCi/g in the sample.

#### *4.3.1.3 Summary of DT-2 Inaccessible Soil Results*

Two sample locations adjacent to accessible soil remediation areas in the southern portion and one sample location in the central portion of DT-2 exceeded the radiological screening level. All other samples collected at the random and biased sampling locations were below the screening level. The three locations exceeding the screening levels are further evaluated in the BRA. See Figure C-11 for the inaccessible samples that exceeded the screening level. No other soil areas associated with DT-2 require further evaluation.

### 4.3.2 Metropolitan St. Louis Sewer District Lift Station Vicinity Property (DT-15)

Forty-four inaccessible soil samples were collected from random sampling locations on the Mississippi River levee located at DT-15 (Figure C-12). The radiological concentrations in soil beneath the levee are not above the screening level.

#### *4.3.2.1 Description of DT-15*

The MSD Lift Station VP (DT-15) is an approximately 2.3-acre property located in the northeastern portion of the SLDS (Figure 1-2). Historical information indicates that the property was mostly undeveloped prior to 1961 with only a minor roadway and a small outbuilding noted on aerial photos taken prior to the construction of the Mississippi River levee. Currently, over 50% of the DT-15 property is covered by the levee. The only building located at DT-15 is the Salisbury Street Pumping Station, which was installed in 1963 (Figure C-12). The Salisbury Street Pumping Station building and the inaccessible soil associated with the Pumping Station were determined to be non-impacted (USACE 2009a). There is no evidence or documentation of MED/AEC-related activities at DT-15.

#### *4.3.2.2 Nature and Extent of Contamination at DT-15*

This section presents the results of the RI sampling of inaccessible soil areas at DT-15.

DT-15 is not within the uranium-ore processing area; therefore, only radiological PCOCs are evaluated.

Inaccessible soil areas at DT-15 include the soil beneath the Mississippi River levee present at the property. Inaccessible soil associated with the levee from the surface to 19 ft bgs was characterized in previous studies and did not indicate any areas of elevated radioactivity (USACE 2001). The focus of RI sampling at the levee at DT-15 was to characterize deep soil located at an approximate depth of 25 bgs, which may have been present during MED/AEC operations and had not been characterized previously (USACE 2009a).

Inaccessible soil samples were collected from random sampling locations, as shown on Figure C-12. The soil samples were collected from depths between 25 and 50 ft bgs. All four locations were moved from the original randomly selected locations due to utilities, slope of the levee, and the presence of rock (rip-rap) cover. A GWS also was conducted on the surface of the levee at DT-15 and no additional soil samples were collected based on the survey results (Figure D-8). The results of these samples, as well as existing data, did not identify radiological contamination above the screening level. A summary of the RI data is shown in Table 4-2 and the analytical results and $SOR_N$ values for each sample location are presented in Table E-15.

#### *4.3.2.3 Summary of DT-15 Inaccessible Soil Results*

The results of the ISOU sampling of deep inaccessible soil at DT-15 showed that the radiological concentrations in soil beneath the levee are not above the screening level and therefore, are not further evaluated in the BRA.

## 4.4 INACCESSIBLE SOILS ASSOCIATED WITH RAILROADS

Three RR main lines traverse the SLDS: the Norfolk Southern RR (DT-3), formerly identified as the Norfolk and Western RR; the Terminal RR Association (DT-9); and the BNSF RR (DT-12), formerly the Chicago, Burlington, and Quincy RR (Figure 1-2). Two of the RRs located at the SLDS are adjacent to, or are constructed within, the north-to-south roads that also traverse the SLDS: North Second Street and Hall Street (Figure 1-2).

Each of the RRs at the SLDS was also in existence during MED/AEC operations. During MED/AEC operations, uranium metal and associated feed materials were processed at the SLDS and the existing RRs were used as transportation corridors for the feed materials and ores. Currently, the RRs are actively used for commercial transportation.

Radiological PCOCs were investigated as part of the RI for all three RR properties. In addition, metal PCOCs were sampled in soil from portions of DT-9 and DT-12, which are located within the uranium-ore processing area (Figure 1-2).

### 4.4.1 Norfolk Southern Railroad (DT-3)

Three hundred fifty-four soil samples were included in the RI evaluation. RI samples were collected as described in Section 2.2, from systematic and biased sampling locations at DT-3 as shown on Figure C-13 and C-14. The results of the RI samples, as well as existing data, were used to evaluate the extent of radiological contamination in inaccessible soil areas. Radiological contamination above the screening level was identified in 2 discrete areas: an area east of Plant 3 and an area east of Plant 10.

#### *4.4.1.1 Description of DT-3*

DT-3, the Norfolk Southern RR VP, consists of two parcels of land: a narrow strip of property that primarily includes the RR main line that is used for commercial transportation, and a second parcel that is a ROW property of approximately 3.5 acres located in the southern portion of the SLDS between Angelrodt Street and Dock Street (Figure 1-2).

The RR main line parcel runs north to south, adjacent and parallel to North Second Street and west of Mallinckrodt Plants 1 and 2, and includes a main line and three spur lines. The southern portion of the RR main line, from Destrehan Street to Dock Street, angles to the southeast (Figure 1-2) and eventually merges with Terminal RR (DT-9) at the Terminal RR Soil Spoils Area. Historically, the Norfolk Southern RR tracks ran parallel to North Second Street between Destrehan and Dock Streets but currently, the southern portion of Second Street no longer exists between Angelrodt Street and Dock Street. The soil in this area, defined as the Second Street Corridor, was addressed as part of the accessible soil remediation.

The main line of DT-3 was in existence prior to MED/AEC operations and therefore, is classified as impacted (USACE 2009a). Any MED/AEC sewers located near or beneath these RR tracks were evaluated as part of this RI and are discussed in Section 4.7.

#### *4.4.1.2 Nature and Extent of Contamination at DT-3*

This section presents the results of the RI sampling of inaccessible soil areas at DT-3.

DT-3 was not considered a uranium-ore processing area, and therefore, the soil sample data evaluation included only radiological PCOCs.

Figures C-13 and C-14 present the locations of the RI and prior characterization samples collected within the RR main line area. The GWS results for the inaccessible soil area are presented on Figures D-9-1 and D-9-2. The GWS indicated two areas of elevated activity. No additional samples were collected based on the results of the GWS because the two areas indicating elevated survey readings were previously defined as systematic or biased soil sampling locations. A summary of the radiological soil sample data is shown in Table 4-2 and the analytical results and $SOR_N$ values for each soil sample are presented in Table E-16.

Surface soil samples were collected in 2001 at several locations along DT-3 main line. At two locations (HTZ27426 and HTZ27427), east of Plant 3, samples exceeded the radiological screening level with $SOR_N$ values calculated at 1.96 and 1.68, respectively. The results of the RI sampling confirmed the presence of radioactivity above the screening level east of Plant 10, which was also detected during the GWS. The three surface soil samples HTZ00447, SLD126835, and SLD126839 located east of Plant 10 have $SOR_N$ values of 7.09, 7.59, and 1.5, respectively.

#### *4.4.1.3 Summary of DT-3 Inaccessible Soil Results*

The inaccessible soil areas on DT-3 that exceed the radiological screening level include one area east of Plant 3 and one area east of Plant 10. These two areas are further evaluated in the BRA. See Figure C-13 and C-14 for the inaccessible areas and samples that exceed the screening level. No other soil areas associated with DT-3 require further evaluation.

### 4.4.2 Terminal Railroad Association (DT-9)

Eight hundred fifty-six soil samples were included in the RI evaluation. RI samples were collected as described in Section 2.2, from systematic, random, and biased sampling locations at DT-9 and the Terminal RR Soil Spoils Area (as shown on Figures C-15, C-16, and C-17). As discussed in Section 1.1.1, *The Memorandum for Record, Subject: Non-Significant Change to the Record of Decision for the St. Louis Downtown Site* (USACE 2005a) amended the geographical area of SLDS to include the Terminal RR Soil Spoils Area. The Terminal RR Soil Spoils Area, which does not have a DT designation, is included in this section with the discussion of DT-9. The results of the RI sampling, as well as existing data, were used to evaluate the extent of radiological contamination in inaccessible soil areas. Radiological contamination above the screening level was identified in nine discrete areas: three areas in the Rail Yard, three areas on the main line, and three areas at the Terminal RR Soil Spoils Area. Cadmium was detected above the screening level at one inaccessible soil location along the mainline RR west of Plant 6. The following section presents a description of DT-9, detailed sampling information on an area-by-area basis, and a summary of the results.

#### *4.4.2.1 Description of DT-9*

The Terminal RR Association VP (DT-9) consists of four main parcels of land and several smaller parcels owned by the Terminal RR Association. The four main parcels consist of the RR main line, the Rail Yard area, the Levee area, and the Terminal RR Soil Spoils Area.

The main line area is adjacent and parallel to Hall Street, bisecting the Mallinckrodt Plant area, with historic MED/AEC plant areas to the east and west of the RR property. The main line area includes several spurs that serviced individual properties within the SLDS boundary (Figures C-15 and C-16).

The Rail Yard area is bounded by MSD to the north, the BNSF RR (DT-12) to the east, Bremen Avenue to the south, and the Terminal RR main line to the east (Figure C-15). Other smaller parcels of the Rail Yard include RR side spurs, which are located west of the RR main line and west of DT-8. The Rail Yard area is currently leased by Lange-Stegmann, who owns property to the southeast of the Rail Yard (DT-37). One building, five storage bins, and a tank are located at the Rail Yard area (Figure C-15).

The DT-9 levee area is located to the east of the rail yard (Figure C-15) in two non-contiguous parcels and includes the levee system for the Mississippi River.

The Terminal RR Soil Spoils Area is the only VP not adjacent to the other SLDS properties and is located approximately one block south of the SLDS (Figure 1-1). The Terminal RR Soil Spoils Area is comprised of City of St. Louis, Norfolk Southern RR, and Terminal RR Association properties as shown on Figure C-17. The Terminal RR Soil Spoils Area is south of Branch Street, north of N. Market Street, east of Produce Row, and west of Grossman Metals Recycling (Figure C-17). The total property area is approximately 19.5 acres (Shaw 2008). Two sets of RR tracks enter into the property from DT-3 (Norfolk Southern RR), but one track ends and another joins the Terminal RR main line along the eastern boundary of the property. The RR track splits again at the southern end of the property, as shown on Figure C-17.

Inaccessible soil areas at DT-9 include the soil associated with the RR tracks present at all parcels of the property and soil beneath the levee on the DT-9 property along the Mississippi River (Figure C-15). Small equipment sheds are present at the Terminal RR Soil Spoils Area; in addition, one recently-built building, five storage bins, and one large tank used by Lange-Stegmann are located at the Rail Yard area (Figure C-15). The equipment shed, storage bins, and tank are defined as non-impacted due to their distance from MED/AEC plant areas and because accessible soil remediation was not conducted adjacent to the structures. The inaccessible soil beneath the new building used by Lange-Stegmann was addressed under the 1998 ROD (USACE 1998a). Any MED/AEC sewers located near or beneath these buildings were evaluated as part of this RI and are discussed in Section 4.7. RI characterization activities were conducted at the Main Line, Rail Yard, Levee, and the Terminal RR Soil Spoils area.

#### *4.4.2.2 Nature and Extent of Contamination at DT-9*

This section presents the results of the RI sampling of inaccessible soil areas at DT-9.

Radiological PCOCs were investigated at the DT-9 properties, while sections of the main line RR located within the uranium-ore processing area (west of Plants 6 and 7) were also sampled for metal PCOCs.

Inaccessible soil samples were collected from systematic, random, and biased sampling locations and at biased sampling locations near accessible soil remediation areas as shown on Figures C-15, C-16 and C-17. The GWS results for each inaccessible soil area are presented on Figures D-10-1 through D-10-3. No additional samples were collected based on GWS results because RI soil samples were already planned for areas where elevated readings were indicated. A summary of the RI radiological data is shown in Table 4-2, a summary of the metals data (analyzed in samples from specific locations) is presented in Table 4-3, and the analytical results and $SOR_N$ values for each soil sample are presented in Tables E-17 (levee), E-18 (rail yard), E-19 (main line radiological), E-20 (main line metals), and E-21 (Terminal RR Soil Spoils Area). Several samples that were previously collected during PDI activities for accessible soil in areas near the RR tracks were used to support RI sampling.

**DT-9 Levee Area:** One biased and five random locations were sampled to investigate the levee area including soil beneath the levee (Figure C-15). Depths up to 37 ft bgs were collected at the random sampling locations. The GWS conducted at the Levee (Figure D-10-1) indicated an area of elevated radiological activity. This area was proposed for biased soil sampling because it was adjacent to an accessible soil remediation area. The results from the biased and random sampling showed that the radiological screening level was not exceeded (Table E-17).

**DT-9 Rail Yard:** Systematic, random, and biased soil locations were proposed for sampling of inaccessible soil beneath the RR tracks. The results of the RI sampling show that three areas exceeded the $SOR_N$ screening level (Figure C-15). Two of the three areas are located along the northernmost set of RR tracks that curve from the south to the east within the rail yard and are adjacent to accessible soil remediation areas. Samples from a cluster of inaccessible soil locations (SLD118901, SLD118905, SLD119017, etc.) showed that areas of inaccessible soil beneath the tracks were elevated. The highest $SOR_N$ value for these locations was 22 detected at location SLD118905 at a depth of 1.0 to 1.5 ft, and radiological contamination was detected at this location to a depth of 3.0 ft where the calculated $SOR_N$ value was 1.66 (Table E-18). Samples collected from SLD118901 and SLD119017 also showed contamination to a depth of approximately 0.5 and 1.5 ft, respectively. Also east of this track area SLD118885 has a sample result above the $SOR_N$ screening level to a depth of 0.5 ft ($SOR_N$ value equal to 1.04). Two biased soil sample locations proposed in the RI WP on the RR track at other areas adjacent to the accessible soil excavation areas were not collected but adequate samples exist along the RR track to evaluate the lateral extent to the west and east.

One sampling location along the RR track that traverses the DT-9 rail yard from the southwest to the northeast also had $SOR_N$ values that exceeded the radiological screening level. Sample SLD118953, collected at a depth of 0 to 0.5 ft, had a calculated $SOR_N$ value of 6.5. The sample collected at location SLD118953 corresponds to an elevated location found by the GWS (Figure D-10-1). Also along this track, another elevated GWS location was sampled at location SLD118957 (Figure D-10-1). Sample results for SLD118597 indicated an $SOR_N$ value of less than 1.0.

**DT-9 Main Line:** Systematic soil sampling locations were proposed at ROW areas from the SLDS boundary on the north (Angelica Street) to the southern boundary at Dock Street (Figures C-15 and C-16). Biased soil samples were collected along the RR tracks within the Mallinckrodt Plant area (Figure C-16) at locations where historic data indicated elevated soil areas or in areas adjacent to accessible soil remediation areas. Metal PCOCs were analyzed in several samples collected adjacent to Plant 6 (Figure C-16). A GWS was conducted along the main line (Figures D-10-1 and D-10-2), and one elevated area was detected near the intersection of DT-9 and Destrehan Street. A soil sampling location was already planned at this area; therefore, an additional sample was not collected based on the GWS results. For discussion purposes the DT-9 Main Line is divided into sections in the following paragraphs.

North of the McKinley Bridge none of the RI samples collected along the main line and at the small parcels areas (Figures C-15 and C-16) exceeded the radiological screening level (Table E-19). The RI results are consistent with previous sampling results for the ROW areas, indicating that radiological contamination exceeding the screening level was not present along this northern portion of the DT-9 main line (USACE 2009a).

From the McKinley Bridge south to Mallinckrodt Street none of the RI samples exceeded the radiological screening level (Table E-19). Soil sample HTZ76747 was collected during accessible soil remediation activities east of Plant 1. This sample was collected by the eastern boundary of the excavation adjacent to Building X railspurs (Figure C-16). The $SOR_N$ value for this sample is 3.55. During RI characterization sample SLD124647 was collected by HTZ76747 and the $SOR_N$ value was less than 1.0; therefore, the extent of contamination appears to be limited to an isolated area.

Between Mallinckrodt Street and Dock Street three previously collected samples at two areas indicated radiological contamination above the $SOR_N$ value of 1.0 (Figure C-16). Location SLD82580, west of Plant 6, was sampled to a depth of 1 ft and the results indicate an $SOR_N$ value of 1.95 (Table E-19). At the second area, near the intersection of DT-9 and Destrehan Street (Figure C-16), two sample locations SLD01023 and SLD124739 indicated radiological contamination to a depth of approximately 1.0 ft (Table E-19). The radiological contamination in this area may extend towards Plant 2, where radiological contamination was detected in the southeast corner (Figure C-2).

Soil samples collected from several locations between Plants 2 and 6 were analyzed for metal PCOCs, as shown on Figure C-16. Soil samples collected in one soil interval at each location were analyzed for arsenic, cadmium, and uranium metal. Cadmium was detected in one sample collected at SLD124687 between 4 and 4.5 ft at a concentration of 69.3 mg/kg, as compared to the screening level of 17 mg/kg (Table E-20). The results of the arsenic and uranium metals analysis at the eight locations sampled at DT-9 mainline for inaccessible soil were below screening levels (Table 4-3).

**Terminal Railroad Soil Spoils Area:** Inaccessible soil areas at this Terminal RR Soil Spoils Area are associated with the RR tracks present at the property. In accordance with the RI WP, inaccessible soil samples were collected from random sampling locations, as shown on Figure C-17. The GWS for this area is presented on Figure D-10-3. No additional samples were collected based on the results of the GWS. A summary of the RI data is shown in Table 4-2 and the analytical results and $SOR_N$ values for each sample location are presented in Table E-21.

The results of the RI sample locations SLD125201 and SLD125217 exceeded screening levels. At SLD125201, the soil sampling interval between 5 and 5.5 ft resulted in an $SOR_N$ value of 1.15. The soil sample collected in the next soil interval between 5.5 and 6.0 ft was 0.24. At SLD125217, the soil sampling interval between 2 and 2.5 ft had an $SOR_N$ value of 3.56 (Table E-21). Samples collected at the next interval, 4.5 to 5.0 ft, had a calculated $SOR_N$ value at background levels (i.e., 0.0).

The maximum radiological concentrations at the Terminal RR Soil Spoils Area, as shown in Table 4-2, were collected from two locations (SLD101312 and HTZ94881) previously collected as part of accessible soil PDI activities. This inaccessible area of detected contamination is located along the Norfolk Southern RR spur in the northern portion of the property (Figure C-17). The $SOR_N$ values for the two locations (SLD101312 and HTZ94881) ranged from 0.51 to 55.5 in samples collected between 0 and 2.5 ft (Table E-21).

#### *4.4.2.3 Summary of DT-9 Inaccessible Soil Results*

The inaccessible soil areas on DT-9 that exceed the screening level include three areas on the Main Line: one east of Plant 1 and two east of Plant 2; three areas in the Rail Yard: two on the northern RR track and one on the RR track traversing southwest to northeast; and three areas at the Terminal RR Soil Spoils Area. Additionally, the cadmium concentration at one inaccessible soil located collected along the DT-9 mainline west of Plant 6 exceeded the screening level. These areas are further evaluated in the BRA. See Figure C-15, C-16, and C-17 for the inaccessible areas and samples that exceed the screening levels. No other soil areas associated with DT-9 require further evaluation.

### 4.4.3 Burlington-Northern Santa Fe Railroad (DT-12)

Four hundred eighty radiological soil samples were included in the RI evaluation. RI samples were collected as described in Section 2.2, from systematic and biased sampling locations at DT-12 (Figures C-18 and C-19). The results of the RI samples, as well as existing data, were used to evaluate the extent of radiological contamination in inaccessible soil areas. Radiological contamination above the screening level was identified in numerous areas. Arsenic contamination above the screening level was also found at several locations east of Plant 7 where radiological contamination was also found. The following section presents a description of DT-12, detailed sampling information on an area-by-area basis, and a summary of the results.

#### *4.4.3.1 Description of DT-12*

The BNSF RR (DT-12) traverses the SLDS in a north-to-south direction on the east side of the SLDS from Angelica Street to Dock Street (Figure 1-2). On the northern boundary of the SLDS (Figure C-18), the main lines of DT-12 that are currently present were in existence prior to the

1940s, although some lines have been removed over the years. In this northern area, spur lines from DT-12 enter into the Terminal RR rail yard (DT-9) and adjoin with RR tracks from DT-9. The DT-12 main line continues under the McKinley Bridge and runs parallel to Mallinckrodt Plants 6 and 7, down to Dock Street at the SLDS southern boundary (Figure C-19). The BNSF RR (DT-12) lines connect to the two other RR VPs (DT-3 and DT-9) at the Terminal RR Soil Spoils Area.

Inaccessible soil areas at DT-12 include the soil associated with the RR tracks present at the property. No buildings are present at DT-12.

#### *4.4.3.2 Nature and Extent of Contamination at DT-12*

This section presents the results of the RI sampling of inaccessible soil areas at DT-12.

Radiological PCOCs were investigated at the DT-12 properties, while sections of the main line RR located within the uranium-ore processing area (east of Plants 6 and 7) were also sampled for metal PCOCs.

Inaccessible soil samples were collected from systematic, random, and biased sampling locations and at biased sampling locations near accessible soil remediation areas as shown on Figures C-18 and C-19. The GWS results are presented on Figures D-11-1 and D-11-2. A summary of the RI radiological data is shown in Table 4-2, a summary of the metals data are presented in Table 4-3, and the analytical results and $SOR_N$ values for each soil sample are presented in Tables E-22 (radiological) and E-23 (metals).

Several samples were previously collected during PDI activities for accessible soil on DT-12 were used to support RI sampling. Accessible soil remediation was conducted during 2010 and early 2011 at the DT-12 ROW as shown by the excavation areas in Figures C-18 and C-19. Several soil samples used to support the RI were excavated at that time.

In the portion of DT-12 north of the McKinley Bridge (Figure C-18), one area east of the Terminal RR rail yard (DT-9) in the DT-12 ROW was excavated. Two previously collected PDI samples to the east of the excavation exceed the radiological screening level. The GWS conducted in the northern portion (Figure D-11-1) did not indicate any additional areas of elevated radioactivity; therefore, no additional samples were collected based on the GWS results. The remaining locations sampled as part of the RI did not exceed the screening level.

South of the McKinley Bridge systematic soil samples collected along the DT-12 main line indicated that radiological contamination above the screening level is present along the west side of the tracks from just north of Destrehan Street to Dock Street (Figure C-19). The vertical extent of contamination was primarily to a depth of 0 to 0.5 ft, although a few locations were contaminated to a depth of 2 ft. A GWS results (Figure D-11-2) did not indicate additional areas of radioactivity that had not already been sampled as part of the RI or PDI.

Biased RI soil samples were collected at locations where historic sampling indicated elevated radiological concentrations or at locations within the ballasted track area (Figure C-19). The results of the biased sampling do not confirm historic sample results. All biased soil samples were below the radiological screening level.

Metal PCOCs were analyzed in samples collected from six biased soil locations along DT-12 and adjacent to Plants 6 and 7 (Figure C-19). Additional samples were collected from the sidewall of accessible soil excavations conducted in the ROW of DT-12. The results showed that arsenic was found in thirteen samples collected from nine locations east of Plant 7 at concentrations above the screening level (60 mg/kg). Arsenic ranged in concentration at these locations from

72.30 to 426 mg/kg. Some of these locations also indicated radiological contamination above the screening level. The results of the cadmium and uranium metals analysis at the six RI locations sampled at DT-12 for inaccessible soil as well as the additional sidewall samples collected were below screening levels.

#### *4.4.3.3 Summary of DT-12 Inaccessible Soil Results*

The inaccessible soil areas on DT-12 that exceed the radiological screening level include an area north of the McKinley Bridge east of DT-9 and large area on the west side of the tracks from just north of Destrehan Street south to Dock Street. Arsenic was also detected in surface soil samples east of Plant 7. These areas are further evaluated in the BRA. See Figures C-18 and C-19 for the inaccessible areas and samples that exceed the screening levels. No other soil areas associated with DT-12 require further evaluation.

## 4.5 ROADWAY VICINITY PROPERTIES (DT-11, DT-19, AND DT-33)

Nearly all of the roadways now in existence at the SLDS were also in existence during MED/AEC operations. No major modifications have been made since MED/AEC operations ceased. The roadways owned by the city of St. Louis within the SLDS boundary are collectively called DT-19, and the roadways owned and maintained by the Missouri Department of Transportation within the SLDS are collectively identified as DT-33. The remaining roadway within the SLDS boundary is the McKinley Bridge roadway (DT-11), which was previously owned by the city of Venice, Illinois, and now is jointly owned by the Illinois Department of Transportation and the Missouri Department of Transportation (State of Illinois 2002). All of the roads within the Mallinckrodt plant property area were once owned by the city of St. Louis but are currently considered private streets and are maintained by Covidien.

There are three north-to-south roads that exist within the SLDS: North Broadway, North Second Street, and Hall Street (Figure 1-2). Both North Second Street and Hall Street are adjacent to two RR properties, DT-3 and DT-9, respectively. There are seven east-to-west roadways that exist within the SLDS including Bremen Avenue, the McKinley Bridge, Salisbury Street, Mallinckrodt Street, Destrehan Street, Angelrodt Street, and Buchanan Street (Figure 1-2). Dock Street defines the southernmost boundary of the SLDS but is not included within the SLDS boundary. Roadways defined as non-impacted and for which no RI sampling was conducted include North Broadway, the McKinley Bridge, and all of the east-to-west running roadways between North Ninth Street and North Broadway (Figure 1-2).

Historic documentation indicates that some of the roadways were used for transportation of uranium-processing residues between the processing plants, to temporary storage areas within the SLDS, or to temporary storage areas at the NC sites when off-site storage was required. The roadways that were identified as most likely to be used for transportation routes from the SLDS to NC were Destrehan Street and North Broadway. Inaccessible soil beneath the roadways may have been contaminated as a result of direct loss of residues from hauling and transportation activities, airborne migration from dust from processing operations or wind erosion from stockpiles, surface water or subsurface migration, or flooding events that may have occurred prior to the establishment of the Mississippi River levee system between 1962 and 1964.

Systematic, random, and biased locations were sampled at several roadways within the SLDS. GWSs were also conducted along each roadway to identify potential areas of radiological contamination. Structures that are located within the footprint of the roadway, such as traffic signals, utility poles, etc., were subject to surveying in accordance with building scoping surveys. No buildings are associated with the roadways.

Portions of Destrehan Street and Hall Street are located within the defined uranium-ore processing area. For these streets, soil samples were collected and analyzed for both radiological and metal PCOCs. For all other roadways, only radiological PCOCs were investigated.

### 4.5.1 North Second Street

Seventy samples were collected from random, systematic, and biased locations along North Second Street. All soil samples collected along North Second Street were below the $SOR_N$ screening level, except at one location to the west of Building L at Plant 1.

#### *4.5.1.1 Description of North Second Street*

Within the SLDS, North Second Street extends from Bremen Avenue to the Mallinckrodt Security Gate 49 (at Angelrodt Street) (Figure C-20). North Second Street is no longer a public street between Angelrodt Street and Dock Street. The soil in this area, defined as the Second Street Corridor, was addressed as part of the accessible soil remediation (USACE 2010b).

During MED/AEC operations, North Second Street was not paved. The block of North Second Street that is located north of the McKinley Bridge is not known to have been used for MED/AEC operations and is not adjacent to plant areas. South of the McKinley Bridge, North Second Street runs alongside Mallinckrodt Plants 1 and 2, which were used for MED/AEC operations.

#### *4.5.1.2 Nature and Extent of Contamination at North Second Street*

Samples were collected from random, systematic, and biased locations along North Second Street as shown on Figure C-20. Random soil samples were collected along North Second Street between Bremen Avenue and the McKinley Bridge. Soil samples also were collected from biased locations near the accessible soil remediation area at DT-8. Systematic and biased samples were collected south of the McKinley Bridge along North Second Street because the roadway is adjacent to MED/AEC plant areas. A summary of the RI radiological data is shown in Table 4-2 and the analytical results and $SOR_N$ values for each sample location are presented in Table E-24.

The results of the RI sampling at North Second Street showed that all of the soil samples collected along North Second Street were below the $SOR_N$ screening level, except at SLD126169 located to the west of Plant 1 (Figure C-20). The sample collected from a depth of 2 to 2.5 ft had an $SOR_N$ value of 2.04. Soil collected at shallower and deeper depths at this location were below the $SOR_N$ screening level of 1.0.

The GWS of North Second Street (Figure D-12) shows one area of elevated radioactivity south of Destrehan Street and east of Plant 10. One systematic soil sample was collected in this location (SLD126185) but there were no screening level exceedances (Table E-24). The GWS of DT-3, the RR adjacent to North Second Street, also indicated elevated radioactivity in this area. Section 4.4.1 discusses the results of the soil sampling conducted at DT-3, which found elevated radiological contamination in the RR track soil within this area.

#### *4.5.1.3 Summary of North Second Street Inaccessible Soil Results*

The results of the RI sampling at North Second Street showed that all of the soil samples collected along North Second Street were below the radiological screening level, except at one location to the west of Building L at Plant 1 (Figure C-20). This area is further evaluated in the BRA.

### 4.5.2 Hall Street

One hundred and ninety-one soil samples from systematic, random, and biased sampling locations were collected along Hall Street (Figure C-21). The results showed that all samples collected along Hall Street during the RI were below the screening levels for both radiological and metal PCOCs. However, the Hall Street RI dataset also includes data from samples collected from the sidewall of accessible soil excavations at the boundary line of Plant 6 and at DT-6. These samples indicate the presence of small areas of inaccessible soil above the screening level.

#### *4.5.2.1 Description of Hall Street*

Within the SLDS, Hall Street runs from south of Bremen Avenue to Dock Street and is adjacent to Terminal RR (DT-9) along its entire length (Figure 1-2). During MED/AEC operations, Hall Street was not paved. The portion of Hall Street that lies north of the McKinley Bridge is on the west side of DT-9 and is adjacent to the Mallinckrodt Parking Lot north of Plant 11 and a small parcel of DT-9. South of the McKinley Bridge, Hall Street is east of DT-9 and adjacent to the west side of Plants 6 and 7, which were used for MED/AEC operations.

#### *4.5.2.2 Nature and Extent of Contamination at Hall Street*

A portion of Hall Street adjacent to Plants 6 and 7 lies within the uranium-ore processing area. Therefore, several soils samples collected at locations adjacent to Plants 6 and 7 were analyzed for both radiological and metal PCOCs. At two locations adjacent to Plant 7W, samples were analyzed only for radiological parameters.

The sample results showed that all samples collected along Hall Street during the RI were below the screening levels for both radiological and metal PCOCs as shown on FigureC-21. A GWS was conducted as part of the RI activities and the results showed that, at two radiologically elevated areas, samples were already collected (Figure D-13). A summary of the RI radiological data is shown in Table 4-2. Metals data are presented in Table 4-3. The analytical results and $SOR_N$ values for each sample location are presented in Tables E-25 (radiological) and E-26 (metals).

The Hall Street RI dataset also includes data from several sidewall samples collected in 2005 as part of accessible soil remediation activities at Plant 6 and at DT-6. The sidewall samples were collected to assess whether contamination from the properties extended under Hall Street. These samples, which were adjacent to Plant 6 and DT-6 as shown on the insets in Figure C-21, indicate that some soil locations remain that exceed the radiological screening level. These locations are on the boundary of each property area and Hall Street. A few of the sidewall sample locations from Plant 6 that exceeded the radiological screening level were within the footprint of the RR track that enters into Plant 6 from DT-9 and that crosses over Hall Street. Although the RR track and soils associated with the track on the Plant 6 property were remediated along with a small area of Hall Street, some inaccessible soil locations (e.g., SLD89259, SLD89260, SLD89263) along Hall Street still remain at radiological concentrations greater than the screening level (Figure C-21 and Table E-25). Additionally, three soil samples collected west of DT-6 within Hall Street (HTZ00262, HTZ75379, HTZ75383) in 2000 and 2003 exceed the radiological screening level and are also adjacent to an inaccessible soil area defined as part of DT-6. Soil samples collected and analyzed for metals PCOCs along Hall Street adjacent to Plant 6 and 7 in the uranium-ore processing area did not exceed screening levels.

#### *4.5.2.3 Summary of Hall Street Inaccessible Soil Results*

Small areas of inaccessible soil exceeding the radiological screening level remain at two locations along Hall Street; at the property boundary of Plant 6 and to the west of the storage building at DT-6. The sidewall samples collected during the accessible soil excavation exceed the radiological screening level (Figure C-21). These areas are further evaluated in the BRA. Inaccessible soil samples collected from remaining areas of Hall Street did not exceed the radiological screening level. Additionally, inaccessible soil samples collected for metal PCOCs did not exceed screening levels.

### 4.5.3 Bremen Avenue

Soil from thirty-three random and biased soil sampling locations were collected during the RI at Bremen Avenue (Figure C-22). The results indicate that the radiological concentrations in soil beneath Bremen Avenue are not above the screening level.

#### *4.5.3.1 Description of Bremen Avenue*

Bremen Avenue runs from North Second Street to the BNSF RR (DT-12) within the SLDS (Figure 1-2). The roadway is located north of the Mallinckrodt Plant area and the McKinley Bridge and was not known to be used for MED/AEC operations. During MED/AEC operations, Bremen Avenue was paved with granite paving blocks and macadam. No inaccessible soil data have been previously collected at Bremen Avenue. Except for one area on DT-8, no accessible soil remediation has been conducted at properties adjacent to Bremen Avenue.

#### *4.5.3.2 Nature and Extent of Contamination at Bremen Avenue*

Bremen Avenue lies outside the uranium-ore processing area and, therefore, the soil sample data evaluation included only radiological PCOCs.

All of the random and biased location samples proposed in the RI WP were sampled except at two locations. The proposed location at the intersection of Terminal RR (DT-9) and Bremen Avenue could not be sampled due to the presence of utilities. Additionally, at SLD121858, only the sample from the 0 to 0.5-ft interval below cover could be recovered for analysis (Figure C-22). At 0.5 ft, concrete was encountered, the location was moved and, at the offset location, concrete of approximately 1.5 ft thickness was still present. Therefore, no additional samples from location SLD121858 could be recovered.

Two additional soil samples were collected (SLD121850 and SLD122107) based on the GWS conducted along Bremen Avenue in October 2009 (Figure C-22). Most of the roadway on the eastern end of Bremen Avenue is paved with asphalt overlaying granite cobblestone. Several elevated readings recorded during the GWS (Figure D-14) were attributed to locations where the asphalt was worn and the underlying granite cobblestone was exposed.

A summary of the RI radiological data from Bremen Avenue is presented in Table 4-2 and the analytical results and $SOR_N$ values for each sample location are presented in Table E-27. The results of the ISOU sampling at Bremen Avenue showed that the radiological concentrations in soil beneath the roadway are not above the screening level.

#### *4.5.3.3 Summary of Bremen Avenue Inaccessible Soil Results*

No inaccessible soil samples exceeded the radiological screening level at Bremen Avenue. Therefore, Bremen Avenue is not further evaluated in the BRA.

### 4.5.4 Salisbury Street

Sixteen soil samples were collected at random sampling locations along Salisbury Street. All of the soil samples collected for Salisbury Street were below the radiological screening level.

#### *4.5.4.1 Description of Salisbury Street*

Salisbury Street runs from North Ninth Street to North Second Street (Figure 1-2). Historically, Salisbury Street ran between Mallinckrodt Plants 1 and 11 but, currently, the roadway is used as an access road to Plant 1. Salisbury Street was not known to be used as a transportation route for MED/AEC operations. During MED/AEC operations, Salisbury Street was paved with granite paving blocks and macadam.

#### *4.5.4.2 Nature and Extent of Contamination at Salisbury Street*

Salisbury Street is not within the uranium-ore processing area and, therefore, the soil sample data evaluation included only radiological PCOCs.

A total of sixteen soil samples were collected at random sampling locations along Salisbury Street between North Broadway and Plant 1 as shown on Figure C-23. A summary of the radiological results is shown in Table 4-2 and the analytical results and $SOR_N$ values for each sample location are presented in Table E-28. A GWS was conducted as part of the RI activities and no additional sampling locations were required (Figure D-15). All of the soil samples collected for Salisbury Street were below the radiological screening level.

The portion of Salisbury Street between North Ninth Street and North Broadway was identified as non-impacted since this block of each roadway was not within the MED/AEC operating area and was not specifically defined as a transportation route used during MED/AEC operations. The soil sampling results collected during the FSSEs at areas west of North Broadway Street concluded that the radiological concentrations in soil are comparable to the SLDS background soil levels.

#### *4.5.4.3 Summary of Salisbury Street Inaccessible Soil Results*

No inaccessible soil samples exceeded the radiological screening level at Salisbury Street. Therefore, Salisbury Street is not evaluated in the BRA.

### 4.5.5 Mallinckrodt Street

Twenty-eight soil samples from systematic and biased sampling locations were collected along Mallinckrodt Street between North Second Street and Terminal RR (DT-9). The results of this RI soil sampling show that no samples exceeded the radiological screening level at Mallinckrodt Street. Analytical results from samples collected in 1999 indicated three small isolated areas located north of Plant 2 Buildings 509, 507, and 502 exceed the radiological screening level. The results from resampling of these locations did not exceed the radiological screening level.

#### *4.5.5.1 Description of Mallinckrodt Street*

Mallinckrodt Street runs from North Ninth Street and dead ends near Terminal RR (DT-9) (Figure 1-2). The roadway during MED/AEC operations was paved with brick or no base was listed (USACE 2009a). The portion of Mallinckrodt Street between North Second Street and Terminal RR (DT-9) is adjacent to Plants 1 and 2 where MED/AEC activities were conducted.

#### *4.5.5.2 Nature and Extent of Contamination at Mallinckrodt Street*

Inaccessible soil samples from systematic and biased sampling locations were collected along Mallinckrodt Street between North Second Street and Terminal RR (DT-9) as shown in Figure C-24. A summary of the RI radiological data and data from previous sampling events is shown in Table 4-2. The analytical results for each sample location and $SOR_N$ values are presented in Table E-29. A GWS was conducted as part of the RI activities and the results showed no radiologically elevated areas (Figure D-16) and therefore no additional samples were collected.

The results of the RI soil sampling show that no soil samples exceeded the radiological screening level at Mallinckrodt Street. Samples were also collected at several biased locations (SLD125237, SLD125241, SLD125245) in order to verify the radiological concentrations in three previous surface soil samples (SLD00963, SLD00975, and SLD00995) collected in 1999. Analytical results from 1999 showed that the $SOR_N$ values for these three samples were 1.1, 1.88, and 1.14, respectively. The results from resampling of these locations did not exceed the radiological screening level. Due to an oversight in the field, metal samples from four locations along Mallinckrodt Street were not collected, per the RI WP. The corresponding radiological samples were collected at the four locations.

Between North Ninth Street and North Second Street and between North Broadway and North Second Street, Mallinckrodt Street has been identified as non-impacted (USACE 2009a). Therefore, no additional sampling was required in these areas.

#### *4.5.5.3 Summary of Mallinckrodt Street Inaccessible Soil Results*

No inaccessible soil samples collected during the RI exceeded the radiological screening level at Mallinckrodt Street. Analytical results from samples collected in 1999 indicated $SOR_N > 1$ values at three small isolated areas located north of Plant 2 Buildings 509, 507, and 502. The results from resampling of these locations did not exceed the radiological screening level; however, these areas are further evaluated in the BRA.

### 4.5.6 Destrehan Street

Two hundred and sixteen soil samples along Destrehan Street were collected at systematic and biased sampling locations between North Broadway and BNSF RR (DT-12). Soil sampling conducted during the RI at locations on Destrehan Street west of Hall Street did not exceed radiological screening levels. Destrehan Street east of Hall Street is scheduled for remediation under the 1998 ROD.

#### *4.5.6.1 Description of Destrehan Street*

Destrehan Street runs from North Ninth Street to the BNSF RR (DT-12) (Figure 1-2). Portions of Destrehan Street run adjacent to Plants 2, 6, 7, and 10, which were used for MED/AEC operations. Destrehan Street was used as a transportation route during MED/AEC operations. Destrehan Street was paved with brick during MED/AEC operations (USACE 2009a). Samples were collected along Destrehan Street between North Broadway to DT-12.

#### *4.5.6.2 Nature and Extent of Contamination at Destrehan Street*

Portions of Destrehan Street located south of Plants 2 and 6 are located within the uranium-ore processing area. Therefore, data evaluation for Destrehan Street included both radiological and metal PCOCs.

The block of Destrehan Street which lies between North Ninth Street and North Broadway was identified as non-impacted (USACE 2009a).

Soil samples were collected at systematic and biased sampling locations as shown on Figure C-25. These samples included one additional biased sampling location (SLD125914) near Plant 2 based on the results of the GWS (Figure D-17). Several of the sampling locations had to be offset from the proposed locations due to utilities. Two sampling locations (SLD125902 and SLD125906) collected as part of the Plant 3 Building 63 investigation were included in the Destrehan Street dataset. Metals also were analyzed in samples collected at some locations within the uranium-ore processing area.

A summary of the radiological results is shown in Table 4-2, a summary of the metal results is shown in Table 4-3, and the analytical results and $SOR_N$ values for each sample location are presented in Tables E-30 (radiological) and E-31 (metals). The average $SOR_N$ value for Destrehan Street was 0.75. Several soil samples exceeded the radiological screening level, primarily within the block of Destrehan Street south of Plant 6; however, this portion of Destrehan Street is scheduled for remediation under the 1998 ROD.

No soil samples collected as part of this RI resulted in radiological exceedances along Destrehan Street between North Broadway and Hall Street (Figure C-25). There were two sample locations (SLD01004 and SLD01239) collected in 1999 where the radiological screening level was exceeded with $SOR_N$ values of 1.09 and 1.02 respectively. These areas were resampled for this RI (SLD125922 and SLD125918) and $SOR_N$ values from these locations were below the screening level.

The results of the GWS between North Broadway and the Terminal RR (DT-9) showed some elevated areas. The elevated areas south of Building 63 at Plant 3 were attributed to the naturally higher background of the granite curbs. At a second location along Destrehan Street and south of Building 510 at Plant 2, a biased soil sample was collected as a result of the GWS review (SLD125914), which showed no concentrations above the screening level. The area south of Building 501 at Plant 2 also showed some elevated GWS readings, but several previously collected samples and soil samples collected during the RI at a nearby location (SLD125918) showed no concentrations above the screening level.

Several inaccessible soil samples were also collected from Destrehan Street south of Plant 6 and analyzed for metal PCOCs (Figure C-25). No arsenic, cadmium, or uranium metal results were detected above screening levels (Table E-31).

#### *4.5.6.3 Summary of Destrehan Street Inaccessible Soil Results*

Samples from two locations collected in 1999 between North Broadway and Hall Street had radiological concentrations that exceed the radiological screening level. These areas were resampled for this RI. The results from resampling of these locations did not exceed the radiological screening level; however, these areas will be evaluated in the BRA.

Destrehan Street, east of Hall Street, will be remediated by USACE as accessible soil under the 1998 ROD and is therefore not further evaluated in the BRA.

### 4.5.7 Angelrodt Street

Ninety-one inaccessible soil samples were collected along Angelrodt Street at systematic and biased sampling locations shown on Figure C-26. Only one location, south of Plant 7S, exceeded the radiological screening level.

#### *4.5.7.1 Description of Angelrodt Street*

Angelrodt Street runs west-to-east from North Ninth Street to the BNSF RR (DT-12) (Figure 1-2). Angelrodt Street is located south of Plant 10, which was used for MED/AEC operations, and south of Plant 7S, which was not used during MED/AEC operations but was used to stockpile scrap material and equipment during demolition and decontamination of Plants 6 and 7 in the early 1960s (Shaw 2004b). Additionally, Angelrodt Street is adjacent to several VPs: Heintz Steel (DT-6), Gunther Salt (DT-4) North, Midwest Waste (DT-7), and the ROW property of DT-3 where accessible soil has been remediated. Angelrodt Street during MED/AEC operations would have been paved with brick or brick and macadam (USACE 2009a).

#### *4.5.7.2 Nature and Extent of Contamination at Angelrodt Street*

Angelrodt Street is not within the uranium-ore processing area and, therefore, the soil sample data evaluation included only radiological PCOCs.

Angelrodt Street between North Ninth Street and North Broadway has been identified as non-impacted (USACE 2009a). This block is not located within the Mallinckrodt plant area, is not affected by surface-water migration or airborne emissions from the plant areas due to the distance from the plant, and is not specifically defined as a transportation route used during MED/AEC operations. Additionally, the soil sampling results collected during the FSSEs at areas west of North Broadway Street concluded that the radiological concentrations in soil are comparable to the SLDS background soil levels.

Inaccessible soil samples were collected at the systematic and biased sampling locations shown on Figure C-26. Several of the proposed sampling locations had to be offset from the original location due to utilities. Two sampling locations (SLD121824 and SLD121828) were added south of Plant 10 as a result of the GWS (Figure D-18). A summary of the radiological results is shown in Table 4-2 and the analytical results and $SOR_N$ values for each sample location are presented in Table E-32.

Only one location, south of Plant 7S, sampled as part of the RI exceeded the radiological screening level (Figure C-26). Five biased soil samples were collected on Angelrodt Street at areas adjacent to accessible soil excavation areas. All of these locations were found to be below the screening level. The systematic sample collected south of Plant 7S, SLD119819, was collected from 0 to 0.5 ft below cover material and had an $SOR_N$ value of 2.96. Previous accessible soil remediation was conducted near this location at Plant 7S.

A slightly elevated area was detected during the GWS along Angelrodt Street (Figure D-18) just south of the office building at DT-10. Samples SLD119791, SLD119795, and SLD119799 were collected near this area during the RI sampling of Angelrodt Street. Soil sampling was also conducted in the ROW of DT-10 (office building) at locations SLD120307 and SLD120311 as shown in Figure C-10. All of these samples are below the radiological screening level.

#### *4.5.7.3 Summary of Angelrodt Street Inaccessible Soil Results*

One location, south of Plant 7S, sampled along Angelrodt Street as part of the RI exceeded the radiological screening level. This area is further evaluated in the BRA.

### 4.5.8 Buchanan Street

Forty-seven soil samples were collected at random and systematic sampling locations along Buchanan Street (Figure C-27). All of the soil samples collected during the RI and previously collected from the Buchanan Street ROW adjacent to accessible soil remediation areas were below the radiological screening level.

#### *4.5.8.1 Description of Buchanan Street*

Buchanan Street is located at the southern end of the SLDS and runs from North Ninth Street to DT-6 where it dead ends near the DT-7 property line (Figure 1-2). Buchanan Street does not run adjacent to any areas known to be used by MED/AEC and was not used as a known transportation route. One block of Buchanan Street is adjacent to accessible soil remediation areas at Gunther Salt (DT-4) North. During the MED/AEC operational period, Buchanan Street was paved with brick or macadam (USACE 2009a).

#### *4.5.8.2 Nature and Extent of Contamination at Buchanan Street*

Buchanan Street is not within the uranium-ore processing area and, therefore, the soil sample data evaluation included only radiological PCOCs.

Buchanan Street between North Ninth Street and North Broadway was identified as non-impacted (USACE 2009a). This block is not located within the Mallinckrodt plant area, is not affected by surface-water migration or airborne emissions from the plant areas due to the distance from the plant, and is not specifically defined as a transportation route used during MED/AEC operations. The soil sampling results collected during the FSSEs at areas west of North Broadway Street concluded that the radiological concentrations in soil are comparable to the SLDS background soil levels. Portions of the unpaved roadway between Midwest Waste (DT-7) and Gunther Salt (DT-4) South were evaluated as part of the accessible soil remediation activities.

Soil samples were collected as part of the RI at random and systematic sampling locations along Buchanan Street (Figure C-27). A GWS was conducted over the extent of the roadway (Figure D-19) and no additional biased soil sampling locations were proposed based on survey results. A summary of the radiological data for Buchanan Street is shown in Table 4-2 and the analytical results and $SOR_N$ values for each sample location are presented in Table E-33.

Five sampling locations along Buchanan Street had to be offset slightly due to utilities. At two locations, SLD120223 and SLD120227 (Figure C-28), soil samples were only able to be collected to a depth of approximately 3 to 4 ft (as opposed to the planned 6 ft depth) because of auger refusal or because soil was saturated.

Several soil samples previously collected from Buchanan Street adjacent to accessible soil remediation areas and all of the soil samples collected during the RI were also below the radiological screening level.

#### *4.5.8.3 Summary of Buchanan Street Inaccessible Soil Results*

No inaccessible soil samples exceeded the radiological screening level at Buchanan Street. Therefore, Buchanan Street is not evaluated in the BRA.

## 4.6 NATURE AND EXTENT OF CONTAMINATION ON BUILDINGS AND STRUCTURES

The RI survey activities for buildings were determined on a property-by-property basis using various information including prior radiological survey data, construction date of the structure, use of the structure by MED/AEC, proximity to accessible soil remediation activities, and distance from MED/AEC operational areas (USACE 2009a). If it was determined that the building may be impacted, radiological scoping surveys were conducted.

Based on the evaluation conducted in the RI WP, the buildings at the following properties were determined to be non-impacted: Plant 7, Mallinckrodt Security Gate 49, Gunter Salt South (DT-4), the McKinley Bridge Structures (DT-11), MSD Lift Station (DT-15), Midtown Garage (DT-29), and Hjersted (DT-34) (USACE 2009a). Additionally, no buildings are present at DT-2, the three RR properties (DT-3, DT-9, and DT-12), Terminal RR Soil Spoils Area, or at any SLDS roadways.

Buildings and structures such as, but not limited to, tanks, containment pads, loading docks, walkways, stairways, piping, pipe rack supports, electrical substations, fire hydrants, utility poles, street signs, and RR signs were included in the scoping surveys. The scoping surveys consisted of scanning for alpha and beta surface activity and fixed-point measurements for total alpha and beta activity. The scoping survey used a gross alpha screening level of 3,900 dpm/100 $cm^2$. The scoping surveys were biased, focusing on areas that are prone to accumulate contamination such as horizontal surfaces, depressions, cracked surfaces, rusted or unpainted surfaces, intake and exhaust vents, etc. While in the field, professional judgment also was used to select biased survey locations.

The results of this RI for soil and buildings are discussed in this section by plant area or VP. There were over 4,600 fixed-point measurements obtained during the RI. Table 4-4 presents the summary of gross alpha survey results. The buildings surveyed are shown on figures provided in Appendix C. Appendix F lists the results of the building scoping surveys and Appendix G contains the figures detailing the building areas where measurements exceeded the gross alpha screening level of 3,900 dpm/100 $cm^2$.

The buildings and structure survey data that exceeded the gross alpha screening level of 3,900 dpm/100 $cm^2$ include:

- A small area less than 1 $m^2$ on the south exterior wall of Building 25 at Plant 1,
- Copper flashing above several sliding doors and the glass skylight panels on the wood storage structure at DT-10, and
- A metal beam at roof level at DT-14.

### 4.6.1 Plant 1 Buildings and Structures

Over 1,800 measurements were obtained, as described in Section 2.2.2, during the scoping surveys at Buildings 3, 4, 5, 6, 7, 8, 10, 10A, 17, 25, 26, B, C, P, L, X, and Z and the area between Buildings L and Z as well as various structures. The results of the scoping surveys, as well as existing data, were used to evaluate the extent of radiological contamination. Radiological contamination above the gross alpha screening level of 3,900 dpm/100 $cm^2$ was identified in 1 discrete area on the exterior wall of Building 25.

#### *4.6.1.1 Description of Plant 1 Buildings and Structures*

Plant 1 currently consists of over 20 buildings and structures and a variety of structures such as tanks, containment pads, a loading dock, and stairways. Plant 1 was used by MED/AEC for developmental work in refining triuranium octoxide feed and experimental processing of radium-containing pitchblende ores from 1942 to 1945. A description of Plant 1 including building history and uses is included in Section 4.2.1.1.

## Table 4-4. Building Scoping Survey Summary

| Property Area | Associated Structure/ Building | Appendix Figure | Gross Alpha Results (dpm/100 $cm^2$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Interior | | | Exterior | | | Rooftop | | |
| | | | Number | Range | Average | Number | Range | Average | Number | Range | Average |
| Plant 1 | Building 3 | C-1 | 18 | 0-66 | 37 | 82 | 0-1,186 | 105 | 25 | 0-2,195 | 275 |
| | Building 4 | C-1 | 4 | 0-49 | 12 | 28 | 0-310 | 67 | 6 | 15-218 | 92 |
| | Building 5 | C-1 | 3 | 0-33 | 16 | 14 | 0-39 | 6 | [a] | [a] | [a] |
| | Building 6 | C-1 | 3 | 16-16 | 16 | 37 | 0-940 | 97 | 24 | 9-1,136 | 346 |
| | Building 7 | C-1 | 5 | 0-163 | 39 | 35 | 0-731 | 184 | 10 | 27-1,614 | 546 |
| | Building 8 | C-1 | 4 | 0-33 | 16 | 61 | 0-1,254 | 165 | 8 | 91-1,345 | 519 |
| | Building 10 | C-1 | 10 | 0-37 | 12 | 48 | 0-1,966 | 193 | 14 | 0-2,009 | 538 |
| | Building 10A | C-1 | 8 | 0-64 | 20 | 21 | 0-646 | 85 | 5 | 29-287 | 126 |
| | Building 16/17 | C-1 | 7 | 0-49 | 16 | 52 | 0-282 | 35 | 45 | 26-2,390 | 307 |
| | Building 25 | C-1 | 30 | 0-51 | 9 | 101 | **0-18,232** [b] | 498 | 45 | 92-3,056 | 1,086 |
| | Building 26 | C-1 | 8 | 0-236 | 111 | 10 | 39-117 | 83 | -- | -- | -- |
| | Building B | C-1 | 22 | 0-57 | 18 | 25 | 0-414 | 51 | 33 | 25-1,377 | 518 |
| | Building C | C-1 | 20 | 0-70 | 26 | 150 | 0-1,675 | 155 | 33 | 0-1,292 | 227 |
| | Building P | C-1 | 12 | 0-70 | 41 | 42 | 0-1,205 | 193 | 12 | 221-1,254 | 656 |
| | Building X | C-1 | 7 | 0-66 | 22 | 128 | 0-928 | 94 | 43 | 0-4,279 | 626 |
| | Building Z | C-1 | 21 | 0-51 | 13 | 336 | 0-2,833 | 256 | 20 | 24-1,828 | 578 |
| | Building L | C-1 | 15 | 0-57 | 23 | 91 | 0-2,878 | 123 | 71 | 5-2,375 | 755 |
| | Utility Measurements [c] | C-1 | NA | NA | NA | 28 | 15-872 | 146 | NA | NA | NA |
| | Area between Buildings L and Z | C-1 | -- | -- | -- | 20 | 0-152 | 35 | -- | -- | -- |
| | Tanks and Loading Dock | C-1 | NA | NA | NA | 22 | 0-571 | 145 | NA | NA | NA |
| | Old Retaining Wall Salisbury | C-1 | NA | NA | NA | 49 | 18-605 | 130 | NA | NA | NA |
| Plant 2 | Building 40 | C-2 | 6 | 0-127 | 58 | 10 | 19-91 | 64 | -- | -- | -- |
| | Building 41 | C-2 | 9 | 0-164 | 57 | 28 | 0-465 | 56 | 5 | 291-1,353 | 719 |
| | Building 501 | C-2 | 22 | 0-18 | 1 | 94 | 0-446 | 60 | 73 | 13-1,280 | 195 |
| | Building 506 | C-2 | [a] | [a] | [a] | 20 | 27-219 | 75 | -- | -- | -- |
| | Building 508 | C-2 | 8 | 0-164 | 57 | 15 | 0-220 | 69 | -- | -- | -- |
| | Building 510 | C-2 | 17 | 0-53 | 19 | 39 | 0-121 | 39 | -- | -- | -- |
| | Utility Measurements [c] | C-2 | NA | NA | NA | 27 | 0-351 | 120 | NA | NA | NA |
| Plant 3 | Building 63 | C-5 | -- | -- | -- | 30 | 0-849 | 150 | 22 | 104-2,599 | 706 |
| | Building 66 | C-5 | -- | -- | -- | 56 | 0-263 | 60 | 22 | 5-3,018 | 880 |
| | Building 62 | C-5 | -- | -- | -- | 30 | 0-1,016 | 137 | 20 | 26-836 | 232 |
| | Utility Measurements [c] | C-5 | NA | NA | NA | 1 | 75-75 | 75 | NA | NA | NA |
| Plant 6 | Building 100 | C-3 | 10 | 0-58 | 16 | 20 | 4-597 | 143 | -- | -- | -- |
| | Building 123 | C-3 | -- | -- | -- | 10 | 0-171 | 57 | -- | -- | -- |
| | Utility Measurements [c] | C-3 | NA | NA | NA | 4 | 18-163 | 74 | NA | NA | NA |
| Plant 8 | Building 90 | C-5 | -- | -- | -- | 70 | 0-1,636 | 367 | -- | -- | -- |
| | Building 91 | C-5 | -- | -- | -- | 54 | 0-1,492 | 343 | -- | -- | -- |
| | Utility Measurements [c] | C-5 | NA | NA | NA | 3 | 22-61 | 44 | NA | NA | NA |
| Plant 9 | Building 96 | C-5 | -- | -- | -- | 146 | 0-1,052 | 149 | 34 | 0-887 | 237 |
| | Northeast Corner Building | C-5 | -- | -- | -- | 5 | 24-67 | 44 | -- | -- | -- |
| | Building 90 | C-5 | -- | -- | -- | 70 | 0-1,636 | 367 | -- | -- | -- |

## Table 4-4. Building Scoping Survey Summary (Continued)

| Property Area | Associated Structure/ Building | Appendix Figure | Gross Alpha Results (dpm/100 cm$^2$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Interior | | | Exterior | | | Rooftop | | |
| | | | Number | Range | Average | Number | Range | Average | Number | Range | Average |
| DT-4 | Administration/ Warehouse | C-8 | 30 | 0-51 | 17 | 155 | 0-372 | 35 | 110 | 10-4,055 | 224 |
| | South Storage Building | C-8 | 4 | 13-97 | 48 | 110 | 0-125 | 30 | 19 | 18-125 | 52 |
| | North Storage Building | C-8 | 20 | 0-213 | 43 | 40 | 0-618 | 91 | 15 | 18-178 | 91 |
| | South Salt Dome | C-8 | [d] | [d] | [d] | 12 | 5-130 | 78 | -- | -- | -- |
| | North Salt Dome | C-8 | [d] | [d] | [d] | 10 | 5-130 | 66 | -- | -- | -- |
| DT-6 | Storage Building | C-9 | 13 | 0-138 | 29 | 76 | 0-317 | 89 | 13 | 41-248 | 116 |
| | Fabrication Building | C-9 | 10 | 0-75 | 18 | 10 | 27-74 | 43 | -- | -- | -- |
| DT-8 | Warehouse | C-10 | 11 | 0-55 | 19 | 15 | 21-231 | 87 | -- | -- | -- |
| | Administration/ Warehouse Building | C-10 | -- | -- | -- | 66 | 0-743 | 133 | 16 | 106-2,128 | 1,194 |
| | Building A | C-10 | -- | -- | -- | 11 | 162-813 | 589 | -- | -- | -- |
| | Building B | C-10 | 10 | 0-51 | 8 | 10 | 0-137 | 66 | -- | -- | -- |
| | Building C | C-10 | 17 | 0-51 | 25 | 10 | 51-203 | 135 | -- | -- | -- |
| | Building D | C-10 | 7 | 0-40 | 26 | 12 | 10-981 | 497 | -- | -- | -- |
| DT-10 | Dry Kiln | C-11 | 5 | 0-46 | 18 | 7 | 0-257 | 142 | -- | -- | -- |
| | Metal Storage Building | C-11 | 14 | 0-330 | 39 | 22 | 0-686 | 123 | -- | -- | -- |
| | Planer Building | C-11 | 5 | 0-43 | 17 | 19 | 0-614 | 111 | -- | -- | -- |
| | Saw Building | C-11 | 24 | 0-72 | 26 | 11 | 0-429 | 109 | -- | -- | -- |
| | Storage Structure | C-11 | -- | -- | -- | 14 | 5-366 | 85 | -- | -- | -- |
| | Storage Structure wood | C-11 | 29 | 0-172 | 33 | 115 | **0-22,476**[b] | 2,100 | 32 | **68-7,335**[b] | 2,172 |
| | Office Building | C-11 | 16 | 0-122 | 33 | 41 | 5-965 | 252 | 14 | 62-2,636 | 519 |
| DT-14 | L-shaped Building | C-13 | -- | -- | -- | 99 | **4-4,760**[b] | 378 | 15 | 30-3,969 | 784 |
| DT-21 | Building | C-13 | -- | -- | -- | 10 | 0-1,271 | 345 | 10 | 0-125 | 56 |
| | Building | C-13 | -- | -- | -- | 41 | 9-1,665 | 347 | 22 | 40-3,427 | 1,102 |
| DT-22 | Building | C-13 | -- | -- | -- | 69 | 0-1,218 | 151 | 21 | 0-1,339 | 398 |
| DT-24 | Building | C-5 | -- | -- | -- | 92 | 0-1,378 | 144 | 20 | 124-3895 | 1,525 |
| DT-25 | Building | C-5 | -- | -- | -- | 31 | 9-1,037 | 141 | 5 | 102-3,302 | 761 |
| Angelrodt Street | Utility Measurements[c] | C-27 | NA | NA | NA | 20 | 0-909 | 102 | NA | NA | NA |

[a] Survey not conducted because field evidence indicates building was constructed after MED/AEC operations.
[b] Locations of measurement results that are greater than the screening level are shown in Appendix G.
[c] Utility measurements included power poles, street signs, fire hydrants, overhead pipe supports, etc.
[d] Interior inaccessible for survey.
-- Sampling not proposed in the RI WP (USACE 2009a).
NA = Not applicable because structure does not have an interior or rooftop.

#### *4.6.1.2 Nature and Extent of Contamination on Buildings and Structures at Plant 1*

Scoping surveys were performed on Buildings 3, 4, 5, 6, 7, 8, 10, 10A, 17, 25, 26, B, C, P, L, X, and Z and the area between Buildings L and Z (Figure C-1). Scoping surveys also were performed on various structures throughout Plant 1, including but not limited to, a wall on the south side of Salisbury Street, containment walls, loading docks, tanks, power poles, stairs, pipe rack supports, fire hydrants, and road/RR signs. Virtually all of the non-building structures appeared to be constructed after cessation of MED/AEC process activities (i.e., after 1957). A summary of the Plant 1 building and structure scoping survey measurements is presented in Table 4-4. Individual building and structure measurement results are presented in Tables F-1 through F-21.

At Plant 1, there were a few field changes to the scoping surveys proposed in the RI WP. These changes were: Based on the age of the previous surveys and information provided, scoping surveys on the roofs of Buildings B, C, L, P, X, and Z and the interior of Building 25 were added to the RI scope and performed.

Due to interferences (i.e., utilities and piping), some building areas were not 100% accessible and were not completely surveyed, this includes: the western portion of the Building 25 south wall; the east walls of Buildings B, C, and 25 (above Building P); and the south and west walls of Building 10. All of the exterior walls cited here were accessible at the ground level and therefore, surveyed to a height of 6 ft. The area of the exterior walls, in Plant 1, that was not accessible for surveying is a small fraction of the total area and did not jeopardize the objective of the scoping survey.

The scoping survey results for the Plant 1 buildings and structures indicated that the maximum alpha activity measurements for the interior, exteriors and roofs were 236, 18,232, and 4,279 dpm/100 $cm^2$, respectively. The maximum roof measurement was taken on clay/ceramic brick-caps which has a glaze with naturally occurring radioactivity. As discussed in Section 2.2.2, a conservative assumption of approximately 50% of the average alpha activity detected (i.e., 950 dpm/100 $cm^2$) on clay/ceramic brick-caps from three properties (DT-21, DT-22, and DT-25) west of North Broadway can be attributed to natural occurring radioactivity for the clay/ceramic brick-caps. Therefore, the survey results for the clay/ceramic brick-caps at the Plant 1 buildings, taking into account the naturally occurring radioactivity, would not exceeded the gross alpha screening level of 3,900 cpm/100 $cm^2$. Individual measurement results are presented in Tables F-1 through F-21.

The scoping survey results for Plant 1 indicated that the only area above the screening level (3,900 dpm/100 $cm^2$) is on the south exterior wall of Building 25 just above ground level. The maximum measurement result on Building 25 was 18,232 dpm/100 $cm^2$. The area of elevated activity is less than 1 $m^2$. Figure G-1 depicts the location of the elevated measurement.

Based on investigations conducted prior to 1994, locations on the interior walls and floors of the first two levels of Building 25 were above the screening level. The 1998 FS indicated that extensive remodeling and painting has resulted in a reduction in surface activity and the potential for employee exposures. The extensive remodeling and painting is likely the reason why the RI scoping survey of the interior of Building 25 did not indicate measurements above the screening level.

#### *4.6.1.3 Summary of Plant 1 Building and Structure Results*

After review of the measurements obtained on the Plant 1 buildings and structures, the only area that exceeded the gross alpha screening level (3,900 dpm/100 $cm^2$) was a small area that was less than 1 $m^2$ in size on the south exterior wall of Building 25. This area is further evaluated in the BRA.

### 4.6.2 Plant 2 Buildings and Structures

Over 370 measurements were obtained, as described in Section 2.2.2, during the scoping survey at Buildings 40, 41, 501, 506, 508, and 510 as well as various structures. The results of the scoping surveys, as well as existing data, did not identify radiological contamination above the screening level on any buildings or structures in Plant 2.

#### *4.6.2.1 Description of Plant 2 Buildings and Structures*

Twelve buildings currently exist at Plant 2, including the larger buildings (501, 502, 503, 504, 505, 507, 509, and 510) and a complex of smaller buildings (40, 41, 506, and 508) (Figure C-2). All of the current buildings at Plant 2 were constructed after MED/AEC operations ceased, except for Buildings 501 and 41. A description of Plant 2 including building history and uses is included in Section 4.2.2.1.

#### *4.6.2.2 Nature and Extent of Contamination on Buildings and Structures at Plant 2*

Scoping surveys were performed on portions of Buildings 40, 41, 501, 506, 508, and 510 as well as on various structures in Plant 2, including but not limited to, power poles, fire hydrants, and road/RR signs (Figure C-2). All of the non-building structures appeared to be constructed after cessation of MED/AEC process activities (i.e., after 1957). A summary of the Plant 2 building and structure scoping survey measurements is presented in Table 4-4.

In Plant 2, there was one field change from the RI WP-proposed scoping surveys. Building 506 was proposed for a scoping survey but, upon field inspection, the building was determined to be new construction and is located approximately 25 ft to the south of the original location. Therefore, a scoping survey of Building 506 was not performed.

The scoping survey results for Plant 2 did not indicate any measurements above the screening level. The maximum alpha activity measurements for the building interiors, exteriors, and roofs were 164, 465, and 1,267 dpm/100 $cm^2$, respectively. Individual building measurement results are presented in Tables F-22 through F-28. No previous characterization data were available for the surfaces of the buildings that currently exist at Plant 2, except for the roof of Building 501. The previous survey results for the Building 501 roof indicated an average alpha activity of 66 dpm/100 $cm^2$ (BNI 1994; DOE 1995).

#### *4.6.2.3 Summary of Plant 2 Building and Structure Results*

No survey results from buildings or structures in Plant 2 were above the screening level. Therefore, no risk evaluation of the soil on buildings and structures at Plant 2 is conducted in the BRA.

### 4.6.3 Plant 6 and Plant 6E Buildings and Structures

Over 40 measurements were obtained during the scoping survey at Buildings 100 and 123 as well as various structures. The results of the scoping surveys, as well as existing data, did not identify radiological contamination above the screening level on any building or structure in Plant 6 and Plant 6E.

#### *4.6.3.1 Description of Plant 6 and Plant 6E Buildings and Structures*

Plant 6 is located in the eastern portion of the Mallinckrodt property and, currently, two Plant 6 areas are defined: Plants 6 and 6E (Figure C-3). The Plant 6 area was previously used for MED/AEC operations, and all buildings once used as processing facilities have since been demolished. The only buildings remaining at the Plant 6 area include Building 101 and Building 100 (both built after MED/AEC operations ceased); a new Building 103, a loading dock south of Building 101; and the RR lines northwest of Building 101, which were replaced during accessible soil remediation (Figure C-3). The Plant 6E property was purchased by Mallinckrodt after MED/AEC operations ceased and includes several chemical processing buildings currently not in use. These buildings (120, 121, 122, 123, 125, 130, and 131) were built in the 1980s and were used by Mallinckrodt for commercial chemical manufacturing operations. A description of Plant 6 and 6E including building history and uses is included in Section 4.2.3.1.

#### *4.6.3.2 Nature and Extent of Contamination on Buildings and Structures at Plant 6 and Plant 6E*

Scoping surveys were performed for portions of Buildings 100 at Plant 6 and Building 123 at Plant 6E (Figure C-3). Scoping surveys also were performed on power poles, fire hydrants, and road/RR signs in Plant 6 adjacent to Destrehan Street. The Plant 6 and 6E buildings and the non-building structures were constructed after MED/AEC operations ceased. A summary of the Plant 6 and 6E building and structure scoping survey measurements is presented in Table 4-4.

In Plant 6, there was one field change to the scoping survey proposed in the RI WP. The interior of Building 101 was proposed for a scoping survey; however, Building 101 is slated for demolition and, therefore, a scoping survey was unnecessary.

The exterior of Building 123, adjacent to the previous remediation, and the interior and exterior of Building 100 were subject to a scoping survey. The scoping survey results for Plant 6 and 6E did not indicate any measurements above the screening level. The maximum gross alpha activity measurements for the interior and exterior surfaces were 58 and 597 dpm/100 $cm^2$, respectively. Individual measurement results are presented in Tables F-29 through F-31.

#### *4.6.3.3 Summary of Plant 6 and Plant 6E Buildings and Structure Results*

The scoping survey results for Plant 6 and 6E did not indicate any measurements above the screening level. The maximum gross alpha activity measurements for the interior and exterior surfaces were 58 and 597 dpm/100 $cm^2$, respectively. Therefore, no risk evaluation of the soil on buildings and structures at Plant 6 is conducted in the BRA.

### 4.6.4 Mallinckrodt West Properties Buildings

Over 600 measurements were obtained during the scoping survey at Buildings 63, 66, 62, 90, 91, 96, northeast corner building and various structures. The scoping surveys, as well as existing data, did not identify radiological contamination above the screening level on any of the buildings for the Mallinckrodt West Properties.

#### *4.6.4.1 Description of Mallinckrodt West Properties*

The Mallinckrodt West Properties include Plants 3, 8, 9, and 11 and the Mallinckrodt parking lot located north of Plant 11. These properties contain seven buildings and various structures. A description of Mallinckrodt West Properties is included in Section 4.2.5.1.

#### *4.6.4.2 Nature and Extent of Contamination on Buildings and Structures at Mallinckrodt West Properties*

Scoping surveys were proposed for portions of Buildings 62, 63, and 66 at Plant 3; Buildings 90 and 91 at Plant 8; and Building 96 and the building in the northeast corner at Plant 9 (Figure C-5). The remaining buildings were designated as non-impacted. Scoping surveys also were performed on power poles and a fire hydrant at Plants 3 and 8. Buildings 62, 63, 66, 90, 91, and 96 were constructed prior to MED/AEC processing operations. Virtually all of the non-building structures appeared to be constructed after MED/AEC process activities ceased (i.e., after 1957). A summary of the Mallinckrodt Wcst building and structure scoping survey measurements is presented in Table 4-4.

The scoping survey results for Mallinckrodt West did not indicate any measurements above the screening level. The maximum building alpha activity measurements for the exteriors and roofs were 1,636 and 3,010 dpm/100 $cm^2$, respectively. Individual measurement results are presented in Tables F-32 through F-40.

#### *4.6.4.3 Summary of Mallinckrodt West Properties Buildings and Structures Results*

Data from over 300 measurements obtained on the Mallinckrodt West Property buildings and structures showed there were no areas that exceeded the screening level. Therefore, no risk evaluation of the soil on buildings and structures at the Mallinckrodt West Properties is conducted in the BRA.

### 4.6.5 Gunther Salt (DT-4) North Vicinity Property Buildings

Over 500 measurements were obtained during the scoping survey at the Administration/ Warehouse Building, two storage buildings and the two salt domes. The results of the scoping surveys, as well as existing data, did not identify radiological contamination above the screening level on any of the buildings.

#### *4.6.5.1 Description of DT-4 Buildings*

Gunther Salt (DT-4) North is occupied by five buildings: two roughly rectangular storage buildings on the western edge of the property; two circular salt storage domes in the middle of the property; and one large brick Administration/Warehouse Building on the eastern half of the property that houses an office, packaging equipment, and packaged salt storage. A RR spur from DT-9 enters the property along the eastern boundary and was constructed prior to 1951. A description of Gunther Salt (DT-4) North VP is included in Section 4.2.7.1.

#### *4.6.5.2 Nature and Extent of Contamination on Buildings and Structures at DT-4*

Scoping surveys were performed on portions of the Administration/Warehouse Building, the two storage buildings, and two salt domes at Gunther Salt North (Figure C-7). Scoping surveys also were performed on utility poles adjacent to Angelrodt Street. A summary of the Gunther Salt (DT-4) North building and structure scoping survey measurements is presented in Table 4-4.

At Gunther Salt (DT-4) North, there was one field change to the scoping survey proposed in the RI WP. Due to safety issues with the mounded salt, the interiors of the salt domes were not surveyed.

The scoping survey results for DT-4 buildings and structures indicated that the maximum alpha activity measurements for the interior, exteriors and roofs were 213, 618, and 4,055 dpm/100 $cm^2$, respectively. The roof measurement was taken on clay/ceramic brick-caps which has a glaze with naturally occurring radioactivity. As discussed in Section 2.2.2, a conservative assumption of approximately 50% of the average alpha activity detected (i.e., 950 dpm/100 $cm^2$) on clay/ceramic brick-caps from three properties (DT-21, DT-22, and DT-25) west of North Broadway can be attributed to natural occurring radioactivity for the clay/ceramic brick-caps. Therefore, the survey results for the roofs at the DT-4 buildings, taking into account the naturally occurring radioactivity, would not exceeded the gross alpha screening level of 3,900 cpm/100 $cm^2$. Individual measurement results are presented in Tables F-41 through F-45.

#### *4.6.5.3 Summary of DT-4 Buildings and Structures Results*

Data from over 500 measurements obtained on the DT-4 buildings show there were no areas that exceeded the screening level for radiological contamination. Therefore, no risk evaluation of the soil on buildings and structures at the DT-4 is conducted in the BRA.

### 4.6.6 Heintz Steel Manufacturing Vicinity Property (DT-6) Buildings

Over 120 measurements were obtained during the scoping survey at two buildings on Heintz Steel VP (DT-6). The results of the scoping surveys, as well as existing data, did not identify radiological contamination above the screening level on any of the buildings on DT-6.

#### *4.6.6.1 Description of DT-6*

Three buildings (Fabrication Building, Storage Building, and the AT&T Complex) are located at the property (Figure C-8). The current, basic property configuration was established between 1973 and 1974; although, a large structure in the northwest corner of DT-6 appears to have been present at the property in 1952.

#### *4.6.6.2 Nature and Extent of Contamination on Buildings and Structures at DT-6*

Scoping surveys were performed on portions of the Fabrication Building and Storage Building, at DT-6 (Figure C-8). Scoping surveys also were performed on utility poles adjacent to Angelrodt Street. A summary of the DT-6 building and structure scoping survey measurements is presented in Table 4-4.

At DT-6 there was a field change to the scoping surveys proposed in the RI WP. The AT&T Transmission Building was built after 1995 and remediation did not occur within the fenced area surrounding the building. The ISOU soil samples adjacent to the AT&T Transmission Building were at background levels. Based on the above information, a scoping survey was not performed on the AT&T Transmission Building.

The scoping survey results for DT-6 did not indicate any measurements above the screening level. The maximum building alpha activity measurements for the exterior and roof were 317 and 248 dpm/100 $cm^2$, respectively. Individual measurement results are presented in Tables F-46 and F-47.

#### *4.6.6.3 Summary of DT-6 Buildings and Structures Results*

Data from over 120 measurements obtained on the DT-6 buildings and structures show there were no areas that exceeded the screening level for radiological contamination. Therefore, no risk evaluation of the soil on buildings and structures at the DT-6 is conducted in the BRA.

### 4.6.7 PSC Metals, Inc. Vicinity Property (DT-8) Buildings

Over 180 measurements were obtained during the scoping survey at the six of nine buildings located on DT-8. The results of the scoping surveys, as well as existing data, did not identify radiological contamination above the screening level on any of the buildings at DT-8.

#### *4.6.7.1 Description of DT-8*

Nine buildings currently exist at PSC Metals, Inc. (DT-8); An Administration/Warehouse Building, a smelter building, a scale house, Building A, Building B, Building C, Building D, Building E and Building F. Scope surveys were conducted at six of the nine buildings. Two buildings (Administration/Warehouse Building and Building A) were surveyed because they were constructed prior to the MED/AEC operations. The other buildings surveyed (Buildings B, C, and D) were adjacent to accessible soil remediation areas. The remaining buildings were considered non-impacted. A description of DT-8 including building locations is included in Section 4.2.9.1.

*4.6.7.2 Nature and Extent of Contamination on Buildings and Structures at DT-8*

Scoping surveys were performed on portions of the Administration/Warehouse Building located in the South Tract; Buildings A, B, and C on North Tract 1; and Building D on Tract 2 at DT-8 (Figure C- 9). A summary of the DT-8 buildings scoping survey measurements is presented in Table 4-4.

The scoping survey results for DT-8 did not indicate any measurements above the screening level. The maximum building alpha activity measurements for the interior, exterior, and roof were 55; 981; and 2,128 dpm/100 $cm^2$, respectively. Individual measurement results are presented in Tables F-48 through F-53.

*4.6.7.3 Summary of DT-8 Buildings and Structures Results*

Data from over 180 measurements obtained on the DT-8 buildings show there were no areas that exceeded the radiological screening level. Therefore, no risk evaluation of the soil on buildings and structures at the DT-8 is conducted in the BRA.

### 4.6.8 Thomas and Proetz Lumber Company Vicinity Property (DT-10) Buildings

Over 360 measurements were obtained during the scoping survey at the three large lumber storage sheds, a drying kiln, a saw building, a planer building, and a brick office building as well as utility poles adjacent to Angelrodt Street were surveyed. The results of these surveys were used to evaluate the extent of radiological contamination. Radiological contamination above the screening level was identified on copper flashing and glass roof skylights on the Wood Storage Building.

*4.6.8.1 Description of DT-10*

The Thomas and Proetz Lumber Company has operated a lumber yard at this location since the early 1900s. Several large lumber storage sheds, a drying kiln, a Saw Building, a Planer Building, and a brick Office building occupy the property (Figure C-10). The only buildings that were constructed prior to MED/AEC processing operations are the brick Office Building and the Wood Storage Building located on the southern boundary. A description of DT-10 including building history and use is included section 4.2.10.1.

*4.6.8.2 Nature and Extent of Contamination on Buildings and Structures at DT-10*

Scoping surveys were performed on portions of all of the buildings at DT-10 (Figure C-10). Scoping surveys also were performed on utility poles adjacent to Angelrodt Street. A summary of the DT-10 building and structure scoping survey measurements is presented in Table 4-4.

The scoping survey results for DT-10 indicated several areas above the gross alpha screening level (3,900 dpm/100 $cm^2$) on the Wood Storage Building. The measurements above the radiological screening level were associated with copper flashing above sliding doors and with the glass panels of four dog house-style skylights. The maximum alpha activity results for the copper flashing and glass skylight panels are 22,476 and 7,050 dpm/100 $cm^2$, respectively. For the remaining buildings, the maximum alpha activity measurements for the interior, exterior, and roof are 330; 965; and 2,636 dpm/100 $cm^2$, respectively. Figures G-2 through G-7 depicts the locations of the elevated measurements on DT-10. Individual measurement results are presented in Tables F-54 through F-60.

#### *4.6.8.3 Summary of DT-10 Buildings and Structures Results*

Radiological contamination above the gross alpha screening level (3,900 dpm/100 $cm^2$) was identified on the copper flashing and glass panels of four dog house-style skylights on the Wooden Storage Structure. Therefore, the soil on the buildings at DT-10 is further evaluated in the BRA.

### 4.6.9 South of Angelrodt Vicinity Property Group (DT-5, DT-13, DT-14, DT-16, DT-17, and DT-18) Buildings

Based on their presence during MED/AEC operations, and its proximity to Plant 10 which was used for MED/AEC activities, the only buildings of the South of Angelrodt Properties that are potentially impacted are the L-shaped building at DT-14. Over 100 fixed-point measurements were obtained during the scoping survey on the L-shaped brick storage building on DT-14 and utility poles adjacent to Angelrodt Street. The results of the scoping surveys, as well as existing data, were used to evaluate the extent of radiological contamination. Radiological contamination above the screening level was identified on a metal beam on DT-14.

#### *4.6.9.1 Description of South of Angelrodt Property Group*

There are three structures of concern located within the South of Angelrodt VP Group. These structures are located on DT-14 and consist of a two-story office/warehouse building on the northwestern portion of the property; an L-shaped brick storage building is located at the northeastern corner of the property, a small brick building immediately south of the L-shaped building. All of the current structures at DT-14 were constructed after MED/AEC operations ceased.

#### *4.6.9.2 Nature and Extent of Contamination on Buildings and Structures at South of Angelrodt Vicinity Property Group*

Scoping surveys were performed on the L-shaped Building at DT-14 (Figure C-28). Scoping surveys also were performed on utility poles adjacent to Angelrodt Street. A summary of the DT-14 building and utility pole scoping survey measurements is presented in Table 4-4.

At DT-14, there was one field change from the RI WP-proposed scoping surveys. A small brick building was proposed for a scoping survey but, upon field inspection, the building had been razed.

The scoping survey results for DT-14 indicated one measurement exceeding the gross alpha screening level (3,900 dpm/100 $cm^2$). The measurement was obtained on a horizontal metal beam going from the L-shaped building to the office/warehouse building. The maximum alpha activity result for the metal beam is 4,760 dpm/100 $cm^2$. There was one clay/ceramic brick-cap with a measurement result of 3,969 dpm/100 $cm^2$. However, as discussed in Section 2.2.2, the glaze on the clay/ceramic brick-caps is naturally occurring radioactive material. The potential radioactivity related to MED/AEC operations does not exceed the screening level on the clay/ceramic brick caps. For the remainder of the building, the maximum alpha activity measurements for the exterior and the roof are 3,179 and 2,771 dpm/100 $cm^2$, respectively. Figure G-8 depicts the location of the measurement exceeding the screening level. Individual measurement results are presented in Table F-61 and F-62.

#### *4.6.9.3 Summary of South of Angelrodt Vicinity Property Group Buildings and Structures Results*

Data show that only a small area on a metal beam at roof level at DT-14 exceeded the gross alpha screening level (3,900 dpm/100 $cm^2$). This area is further evaluated in the BRA.

### 4.6.10 West of Broadway Property Group (DT-20, DT-21, DT-22, DT-23, DT-24, DT-25, DT-26, DT-27, DT-28, DT-30, DT-31, DT-35, DT-36 and Mallinckrodt Parking Lots)

Over 300 measurements were obtained, as described in Section 2.2.2, during the scoping survey at the West of Broadway Property Group. The five buildings with measurements were located on DT-20, DT-21, DT-22, DT-24 and DT-25. The results of the scoping surveys, as well as existing data, did not identify radiological contamination above the screening level on any of the buildings on these properties.

#### *4.6.10.1 Description of West of Broadway Property Group Buildings and Structures*

The buildings on the West of Broadway Property Group that were surveyed are on DT-20, DT-21, DT-22, DT-24, DT-25, and DT-26. These buildings were constructed prior to MED/AEC activities and are adjacent to MED/AEC processing areas. The structures at the remaining properties (DT-23, DT-27, DT-28, DT-29, DT-30, DT-31, DT-35, and DT-36) are classified as non-impacted based on the evaluation presented in the RI WP (USACE 2009a).

The Richey VP (DT-20) was utilized as a commercial electric motor repair shop. The property was occupied by two buildings joined as one extending across the eastern and southern portions of the property.

The Favre VP (DT-21) has two buildings located on the property. A two-story brick building on the northern portion of the property is used as a residence. The larger one-story building to the south is a commercial building.

The Tobin Electric VP (DT-22) is currently occupied by two structures: a two-story residential building at the southeast corner of the property and a single-story building located directly north of the residence currently utilized as a commercial hardware store.

The Bremen Bank VP (DT-24) consists of a bank and associated asphalt parking lot.

The Eirten's Parlor VP (DT-25) is occupied by a two-story building currently used as a restaurant. The area behind the building is asphalt covered.

The Union Local 1887 VP (DT-26) consists of a two-story building used as offices for union business. The original DT-26 building was razed and a new building was constructed.

#### *4.6.10.2 Nature and Extent of Contamination on Buildings and Structures at West of Broadway Property Group*

Scoping surveys were performed on portions of the buildings on DT-20, DT-21, DT-22, DT-24, and DT-25. Construction of a new building at DT-26 was in progress and, therefore, a scoping survey was not performed. The building on DT-20 was razed in the summer of 2010 after the exterior was surveyed. The DT-20 building roof survey proposed in the RI WP was not performed due to safety reasons (instability). A summary of the buildings scoping survey measurements is presented in Table 4-4.

The scoping survey results for DT-20, DT-21, DT-22, DT-24, and DT-25 did not indicate any measurements above the screening level. The maximum alpha activity measurements for the exterior and roof were 1,665 and 3,895 dpm/100 $cm^2$, respectively. Individual measurement results are presented in Tables F-63 through F-67.

#### *4.6.10.3 Summary of West of Broadway Property Group Buildings and Structures Results*

Data from over 300 measurements obtained on the West of Broadway Property Group Buildings show that no areas were found over the screening level for radiological contamination. Therefore, no risk evaluation of the soil on buildings and structures at the West of Broadway Property Group is conducted in the BRA.

## 4.7 NATURE AND EXTENT OF CONTAMINATION ASSOCIATED WITH SEWERS

Activities conducted as part of the sewer investigation included collecting sediment samples from manholes and surface drains (grate inlets) and collecting soil samples adjacent to sewer lines. The sampling activities focused on the sewers that were used for MED/AEC operations as well as sewers that could contain MED/AEC contamination due to receiving runoff from contaminated areas. In addition, background sediment sampling was conducted in manholes located along sewer lines upstream of the Mallinckrodt facility.

Because sediment samples collected from drains, manholes, surface grates, and sewers used for MED/AEC operations were not analyzed for metals during historical investigations, the metals associated with the pitchblende and domestic ores (e.g., arsenic, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, thorium, vanadium, and zinc) were identified as PCOCs for the RI sampling and analysis of sediment in sewer manholes/grates and in soil adjacent to the sewers. The screening levels used for metals contamination in sewer sediment are the USEPA's industrial RSLs for soil that target a CR and non-cancer HI of $10^{-6}$ and 1.0, respectively. For soil adjacent to sewers, the screening levels originally derived in the 1998 FS (USACE 1998b) for arsenic, cadmium, and elemental uranium are used, in addition to USEPA's industrial soil RSLs for the remaining metal PCOCs. An $SOR_N$ value equal to or greater than unity (1.0) is used as a screening level for radionuclides in sediment and soil adjacent to the sewers.

This section presents a general description of the sewer system (Figure H-1), followed by a summary of the RI results for the sewer sampling conducted at the upstream areas (Figure H-2) and at each plant or downstream VP (Figures H-3 through H-7). Sampling of sewer sediment and soil adjacent to sewer lines was conducted in Plants 1, 2, 6, and 7N and the following SLDS VPs: St. Louis City Property VP (DT-2); PSC Metals, Inc. VP (DT-8); Illinois Department of Transportation and Missouri Department of Transportation VP (DT-11); and the BNSF RR (DT-12). The results of sewer sampling conducted at locations along streets are discussed in those sections dealing with the closest adjacent plant or VP. The sewers used for MED/AEC operations at Plant 10 were included and evaluated in the RI WP and were determined to be non-impacted; thus, they are not discussed in the RI.

Maps of the sewer system for each of the areas discussed below are provided in Appendix H: Figure H-3 (Plant 1), Figure H-4 (Plant 2), Figure H-5 (Plant 6), Figure H-6 (Plant 7N, DT-12 and DT-2) and Figure H-7 (DT-8 and DT-11). Figure H-8 is an oversized map that provides an overview of all the sewer sampling locations at the SLDS. Three use categories (MED/AEC, commercial, and both MED/AEC and commercial) are designated on these figures based on the available information. The references used to prepare these figures include: Austin Company (1966); BNI (1990b); Horner and Shifrin, Inc. (1965, 1970, 1971, and 1973); Mallinckrodt (1967a, 1967b, 1971, 1983, 1985a, 1985b, 1989a, 1989b, 1991, 1992); MSD (1965 and 2000); USACE (1994); Warren and Van Praag, Inc. (1980); and Westlake Construction Company (1973).

During MED/AEC operations, most process, storm, and sanitary effluents for Mallinckrodt were collected in a combined sewer system. Figure H-1 shows the current understanding of the location of the sewers at the SLDS and is based on available information documenting the construction and subsequent modifications to the sewers. The sewer system consists of the following types of structures, listed in the direction of flow: (1) individual building drains (usually with diameters of 2 to 4 in) that discharge into (2) building sewers (typically with diameters of 4 to 6 in) that empty into (3) lateral sewers that feed into (4) mains, and then discharge to (5) trunk lines and interceptor sewers. Effluent entered the combined system from the MED/AEC areas and passed through the system, ultimately discharging to the Mississippi River (prior to December 1970). Currently, sewer flow from the SLDS discharges to the MSD Bissell Point Treatment Plant. Additional components of the sewer system include manholes, curb drains, surface drains, and sumps. Sewers at the Mallinckrodt property were predominantly constructed from vitrified clay pipe (VCP) and vitrified brick sealed with bituminous tar or cementitious materials. The bedding material commonly used during this era was granulated rock material, but some sewers may have been constructed without any bedding material (BNI 1990b).

### 4.7.1 Upstream (Background) Sewer Sampling

This section briefly summarizes the results of the background sediment sampling conducted for this RI. To assist with evaluating the PCOCs for sewers, background sediment samples were collected from manholes in areas upstream of the SLDS. Results were used to develop a statistical background concentration for each of the PCOCs identified in Table 4-1. The analytical results for the sewer sediment samples collected in MED/AEC areas were compared to these background values, as well as to the screening levels, to support evaluation of the nature and extent of metal and radionuclide contamination in sewers. The background concentrations provide a reference point for evaluating if concentrations in SLDS sewers are a result of historical MED/AEC releases. In addition, the background values for radionuclides are used in the calculation of $SOR_N$ values for the site sediment samples.

All background manhole sampling locations were located along sewers in the industrial area located upstream of the Mallinckrodt Plant area (Figure H-2). Field changes to some of the proposed manhole sampling locations were made due to access restrictions and safety issues encountered in the field. General observations concerning the site conditions at each sampled manhole location as well as lithologic descriptions of the sediment samples are provided on the field boring log forms included in Appendix A. The background sediment samples are generally described as consisting predominantly of fine to medium sand with varying amounts of silt and traces of fine gravel.

A total of 11 background sediment samples were collected from manholes located upstream (west) of the Mallinckrodt facility during this RI. The RI WP identified eight background sediment sample locations, but 3 manhole locations (SLD123754, SLD123755, and SLD123756) located further upstream of the plant were also sampled to provide a more statistically robust background dataset. The data from the 11 upstream sewer sediment sampling locations provide an appropriate dataset for establishing background sediment concentrations for metals and radionuclides. Prior to determination of background values, statistical outlier evaluations were conducted. Results identified as outliers were removed from the background data set prior to calculations of summary statistics, goodness of fit (GOF), and background values. A detailed description of the methodology used to develop the background statistics is presented in Appendix I.

For sediment associated with the sewers, the 9 radionuclides identified as PCOCs include Ra-226, Ra-228, Th-228, Th-230, Th-232, U-235, U-238, Ac-227, and Pa-231. The maximum detected values for Ra-226, Th-230, Th-232, and U-238 in background sewer sediment samples are 3.4, 3.2, 3.9, and 3.5 pCi/g, respectively. Table J-1 in Appendix J presents the radiological results for the background sediment samples collected during the RI.

For sediment associated with the sewers, the 12 metals identified as PCOCs include arsenic, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, uranium, vanadium, and zinc. Table J-2 presents the results for the metal PCOCs in background sediment samples. Arsenic concentrations exceed the risk-based screening level for sewer sediment (1.6 mg/kg) at nine of the 11 background sediment sampling locations. Cadmium and lead exceed their screening levels (17 mg/kg and 800 mg/kg, respectively) at two background locations

Table 4-5 summarizes the background statistics that were calculated for each PCOC, including the frequency of detection (FOD), mean, minimum, and maximum detected concentration; standard deviation; 95% UCL on the mean; and 95% upper tolerance limit (UTL) of the 95th percentile. Because all 95% UTL values are greater than the maximum detection, the sediment background value for each metal was set equal to the lower of the 95% UCL and the maximum detected background concentration. The use of the lower of the two concentrations is consistent with the method outlined in the *Guidance for Conducting Risk Assessments and Related Risk Activities for the DOE-ORO Environmental Management Program* (DOE 1999).

The sediment background values for radionuclides are used in the calculation of $SOR_N$ values for the site sewer sediment samples. To be consistent with the methodology used to calculate the soil background values for the SLDS in the *Background Soils Characterization Report for the St. Louis Downtown Site* (USACE 1999a), the background values for radionuclides in sewer sediment were set equal to the mean value rather than the lower of the 95% UCL and the maximum detected background concentration.

The sewer sediment background values derived for radionuclides and metals are used for comparisons with the radiological and metals results for the on-site sewer sediment samples (as shown on Tables J-3 and J-4, respectively).

### 4.7.2 Plant 1 Sewers

The RI sewer sampling conducted at Plant 1 involved sediment sampling of 11 manholes/grate inlets, and sampling of soil in 17 soil borings drilled adjacent to portions of the sewer system. The sediment and soil sampling locations for Plant 1 are presented on Figure H-3. The sediment and soil samples were analyzed for the 9 radiological and 12 metal PCOCs as discussed in Section 2.1. This section presents a description of the Plant 1 sewer system and detailed information concerning the nature and extent of contamination based on the sampling results for Plant 1 sewers, followed by a summary of the results. The RI results indicate that historical releases from a segment of a 15-in sewer line located east of former Building G have resulted in MED/AEC-related radiological and metals contamination in adjacent subsurface soil. Sediment samples from eight manhole locations exceeded arsenic screening levels, and one sediment sample exceeded the cadmium screening level. Soil samples from seven borings located adjacent to sewer lines exceeded soil screening levels for the metals arsenic, cadmium, and/or lead.

#### *4.7.2.1 Description of Plant 1 Sewers*

During MED/AEC operations, Plant 1 was served by two parallel sewer lines (one private and one public) located along the northern edge of Plant 1 (Figure H-3). These sewers extended west to east along Salisbury Street and discharged directly into the Mississippi River. Mallinckrodt owned and operated the 3- x 4-ft brick private sewer, which was constructed sometime prior to initiation of MED/AEC activities. MSD owns and maintains the 4.5-ft-diameter brick public

## Table 4-5. Background Sewer Sediment Results

| PCOC | Units | No. of Detections | Total No. of Analyses | FOD (%)(2) | Minimum Detection | Maximum Detection | Mean | Standard Deviation | Distribution Type(3) | 95% UCL(4) | 95/95 UTL(4) | Sediment BV(5) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ac-227 | pCi/g | 7 | 11 | 64 | 0.015 | 0.206 | 0.0442 | 0.0867 | N | 0.092 | 0.288 | **0.04** |
| Pa-231 | pCi/g | 7 | 11 | 64 | 0.0003 | 0.784 | 0.0736 | 0.351 | N | 0.265 | 1.061 | **0.07** |
| Ra-226 | pCi/g | 10 | 10 | 100 | 0.648 | 1.14 | 0.918 | 0.153 | N | 1.007 | 1.363 | **0.92** |
| Ra-228 | pCi/g | 10 | 10 | 100 | 0.216 | 0.702 | 0.356 | 0.185 | X | 0.466 | 0.702 | **0.36** |
| Th-228 | pCi/g | 10 | 10 | 100 | 0.164 | 0.718 | 0.417 | 0.19 | N | 0.527 | 0.969 | **0.42** |
| Th-230 | pCi/g | 10 | 10 | 100 | 0.689 | 1.25 | 1.02 | 0.184 | N | 1.127 | 1.556 | **1.02** |
| Th-232 | pCi/g | 10 | 10 | 100 | 0.233 | 0.677 | 0.413 | 0.167 | N | 0.51 | 0.898 | **0.41** |
| U-235 | pCi/g | 7 | 11 | 64 | 0.009 | 0.235 | 0.0252 | 0.109 | N | 0.085 | 0.332 | **0.03** |
| U-238 | pCi/g | 8 | 10 | 80 | 0.254 | 1.05 | 0.302 | 0.781 | X | 1.378 | 1.05 | **0.30** |
| Arsenic | mg/kg | 10 | 11 | 91 | 1.2 | 19.6 | 8.668 | 5.802 | N | 11.84 | 25 | **11.84** |
| Cadmium | mg/kg | 9 | 9 | 100 | 0.74 | 7.6 | 3.358 | 2.801 | G | 6.165 | 21.38 | **6.17** |
| Cobalt | mg/kg | 10 | 11 | 91 | 2.1 | 15.1 | 6.436 | 4.427 | N | 8.856 | 18.9 | **8.86** |
| Copper | mg/kg | 8 | 8 | 100 | 14.4 J | 249 J | 99.93 | 85.29 | N | 157.1 | 371.7 | **157.1** |
| Lead | mg/kg | 10 | 10 | 100 | 31.1 | 1,090 J | 405.3 | 338.5 | N | 601.5 | 1,391 | **601.5** |
| Manganese | mg/kg | 10 | 10 | 100 | 90.7 J | 1,040 J | 452.4 | 300.6 | N | 626.2 | 1,327 | **626.2** |
| Molybdenum | mg/kg | 8 | 11 | 73 | 1.3 | 12.6 | 5.045 | 3.863 | N | 7.156 | 15.92 | **7.16** |
| Nickel | mg/kg | 10 | 10 | 100 | 4.7 | 56.5 | 23.89 | 17.46 | N | 34.01 | 74.7 | **34.01** |
| Selenium | mg/kg | 2 | 11 | 18 | 4.4 | 4.6 | 2.008 | 1.7 | N | 2.937 | 6.794 | **2.94** |
| Uranium | mg/kg | 7 | 10 | 70 | 7.5 | 23.1 | 13.62 | 7.32 | N | 17.86 | 34.93 | **17.86** |
| Vanadium | mg/kg | 9 | 9 | 100 | 4.7 | 22.5 | 15.57 | 6.116 | N | 19.36 | 34.1 | **19.36** |
| Zinc | mg/kg | 9 | 9 | 100 | 112 J | 962 J | 479.7 | 290 | N | 659.4 | 1,359 | **659.4** |

**Notes:**
(1)Statistical parameters were determined without outlier results. All outliers and statistical parameters were determined using USEPA's ProUCL statistical program (see Appendix I).
(2)FOD is expressed as a percentage of detections out of the total number of samples analyzed.
(3)Distribution type, G - Gamma distribution; N - Normal distribution; X – Data do not follow a normal, lognormal or gamma distribution.
(4)95% UCL of the arithmetic mean concentration, and 95/95 UTL were determined at the 5% significance level. The 95/95 UTL represents the 95% UTL determined at 95% coverage.
(5) Background Values (BVs) for metals are the lesser of the 95% UCL and the maximum detection. BVs for radionuclides are the mean values.

sewer, which was constructed by the city of St. Louis sometime prior to 1927 and is still in operation. The public sewer runs parallel to, but slightly north of, the private sewer and is also several feet higher in elevation than the private sewer. In the 1970's, the private sewer collapsed and was abandoned. At this time, the plant began discharging to the public sewer.

*4.7.2.2*

Most of the wastewater generated from Plant 1 was discharged into the 3- x 4-ft private brick sewer main along Salisbury Street (Figure H-1). There were two entry points into the private sewer from Plant 1. One was located near Building 25 and the other was near former Building T (Figure H-3). The wastewater generated from the Plant 1 buildings utilized during the MED/AEC operations was gravity-discharged into the VCP Plant 1 collection system and then discharged into the 3- x 4-ft private brick sewer. Some roof downspouts and dedicated storm sewers tied into the 4.5-ft-diameter public brick sewer main.

Two types of radioactively contaminated waste materials were transported in the sewer system at Plant 1: (1) MED/AEC wastes and (2) wastes originated from Mallinckrodt commercial work (C-T operations). Plant 1 was used by MED/AEC for refining triuranium octoxide feed from 1942 to 1945. Developmental work at the laboratory level took place in the northwest corner of Plant 1, specifically the Building 25 laboratory, Building K, and the alley between Buildings K and 25. Building 25 also housed the commercial (C-T operations) research laboratories from 1962 until 1967 when the laboratories were moved to Building 250 in Plant 5. During the period when the commercial research laboratories were located in Building 25, the wastewater was gravity-discharged into the 3- x 4-ft private brick sewer main.

In the early 1970s, commercial wastewater from Plant 1 was rerouted by pumping via a 16-in-diameter force main to two newly constructed neutralization basins in Plant 7W. The discharge point north of Building 25 (MH-60) was capped off and the sewers flowing to that discharge point were redirected to a new pump station installed at the discharge point near Building T (Figure H-3). Connections to the 3- x 4-ft private brick sewer were capped off and the private sewer was abandoned in place.

On a 1985 Mallinckrodt Drawing [No. 6326-201-5 "St. Louis Plants 1 and 2 Existing Sewer System" (1985a)], Mallinckrodt identified specific areas along the Plant 1 sewer lines where leaks or problems occurred with the pipes or joints. Examples of disrepair, noted on Figure H-3, include broken and cracked pipe, little or no mortar, loose brick, and leaking pipe joints. It is not known if repairs were made to the sewer lines in Plants 1 during 1985 (Mallinckrodt Chemical Works, Inc. 1985a). Figure H-3 also identifies the portions of the sewers removed during the excavation activities performed under the 1998 ROD (USACE 1998a). The sewer areas that were removed include portions of the 10- and 6-in sewer lines located east and south of the K-pad excavation area in Plant 1.

*4.7.2.3 Nature and Extent of Contamination at Plant 1 Sewers*

This section presents the results of the RI sampling of sediment from sewer manholes/grates and soil adjacent to the sewers at Plant 1.

**Sediment Sampling Results:** Based on the results of the manhole sampling at Plant 1, no radiological PCOCs are present in sediment at concentrations exceeding the sediment screening level. Therefore, radiological PCOCs in sewer sediment samples are not evaluated for potential risk in thc BRA. $SOR_N$ values ranged from 0.00 to 0.27. The maximum $SOR_N$ value (0.27) was reported for a sediment sample collected at SLD123496, located west of Building F along the 10-in sewer line extending north from the eastern corner of the former Building A area.

Arsenic concentrations in sediment samples from eight Plant 1 manholes exceeded the RI screening level for sediment (1.6 mg/kg). The arsenic screening level for sediment is based on USEPA's regional industrial risk-based screening levels for soil (USEPA 2011a). Sediment sample SLD123489, collected from a manhole located along the Salisbury Street private brick sewer, had a cadmium concentration of 17.6 mg/kg. This value exceeds the sediment background value (6.2 mg/kg) but only slightly exceeds the risk-based screening level for cadmium (17 mg/kg). The sewer sediment results for the radiological and metal PCOCs at Plant 1 are provided in Tables J-3 and J-4, respectively.

**Soil Sampling Results:** Table 4-6 presents a summary of the RI soil sampling results that exceeded the screening level for the radiological PCOCs for sewers at the SLDS. Based on the sampling results for soil samples collected adjacent to Plant 1 sewer lines, one Plant 1 soil boring location had concentrations that exceed the screening level for radionuclides ($SOR_N$ >1.0). The $SOR_N$ values calculated for two soil samples (at depths of 7 to 7.5 and 11.5 to 12 ft bgs) from this boring (SLD124540, located east of former Building G) exceeded the screening level.

These results indicate that the soil adjacent to a 15-in sewer line that extends north of the northwestern corner of Building 8 has been impacted. This sewer line is located approximately 9 to 10 ft bgs. The boring is located near the portion of the line that was reported to be "severely broken, near collapse" in a 1985 Mallinckrodt drawing (Mallinckrodt Chemical Works, Inc. 1985a). Concentrations of radionuclides detected in samples from SLD124540 were highest in the deepest sample, thus indicating that the vertical extent of contamination in this boring is not fully defined. Soil samples from borings located approximately 100 ft south (SLD125521) and 200 ft north (SLD124560) of SLD124540 and along the same sewer line did not exceed the radiological screening level. The radiological results for the soil samples collected adjacent to the Plant 1 sewers are presented in Table J-5.

Based on the RI sampling results for soil samples collected from soil borings installed adjacent to Plant 1 sewer lines, seven Plant 1 soil boring locations exceed soil screening levels for the metals arsenic, cadmium, and/or lead. The metals contamination was commingled with radiological PCOCs in only one of these soil boring locations (SLD124540, located east of former Building G). Concentrations of arsenic, cadmium, and lead in soil samples collected from SLD124540 exceed their risk-based screening levels. The maximum arsenic (130 mg/kg) and lead (1,450 mg/kg) concentrations detected in this boring were reported for the 6- to 6.5-ft-deep split sample. The maximum cadmium concentration (33.8 mg/kg) was detected in the sample collected from 9.5 to 10 ft bgs.

At the six other Plant 1 soil boring locations where arsenic, lead, and/or cadmium exceeded their soil screening levels, the maximum concentrations detected were 60.9 mg/kg arsenic at SLD124546 (located northeast of Building 25); 1,260 mg/kg lead at SLDS124570 (located at the southeast corner of Plant 1); and 1,730 mg/kg cadmium at SLD124548 (located east of Building 25). The soil screening levels for arsenic, lead, and cadmium are 60 mg/kg, 800 mg/kg, and 17 mg/kg, respectively. None of the Plant 1 soil samples exceeded screening levels for the remaining metal PCOCs (i.e., cobalt, copper, manganese, molybdenum, nickel, selenium, uranium, vanadium, and zinc).

A summary of the soil results that exceeded screening levels for the metal PCOCs is provided in Table 4-7. A full list of the metal PCOC results for the soil samples collected adjacent to the Plant 1 sewers is presented in Table J-6.

## Table 4-6. Sewer Soil Data: Stations with Radiological Potential Contaminant of Concern Concentrations Exceeding Remedial Investigation Screening Levels

| Area | Station ID | Sample ID | Approximate Depth [a] of Sewer (ft bgs) | Date | Start Depth [a] (ft bgs) | End Depth [a] (ft bgs) | Ac-227$_G$ (pCi/g) | Pa-231$_G$ (pCi/g) | Ra-226$_G$ (pCi/g) | Ra-228$_G$ (pCi/g) | Th-228$_G$ (pCi/g) | Th-230$_G$ (pCi/g) | Th-232$_G$ (pCi/g) | U-235$_G$ (pCi/g) | U-238$_G$ (pCi/g) | SOR$_N$ (pCi/g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant 1 | SLD124540 | SLD126647 | 9 | 04/19/10 | 5.5 | 6 | 0.33 | -0.05 | 2.13 | 1.06 | 2.12 | 4.09 | 1.59 | 0.21 | 5.83 | 0.26 |
| | | SLD124540 | | | 7 | 7.5 | 2.11 | 1.43 | 3.78 | 0.78 | 1.22 | 24 | 1.04 | 1.64 | 24.80 | 1.94 |
| | | SLD124541 | | | 9.5 | 10 | 0.70 | -0.07 | 2.68 | 0.55 | 0.57 | 11.80 | 0.57 | 0.49 | 12.40 | 0.88 |
| | | SLD125650 | | | 11.5 | 12 | 1.71 | 1.5 | 4.66 | 1.08 | 1.19 | 20.30 | 1.20 | 3.69 | 78.60 | 2.78 |
| Plant 2 | SLD124580[b] | SLD124580 | 10 | 03/12/10 | 8 | 8.5 | 0.19 | 1.26 | 1.42 | 0.59 | 0.79 | 1.18 | 0.60 | 1.73 | 34.70 | 0.67 |
| | | SLD124581 | | | 9.5 | 10 | 0.08 | -0.47 | 1.96 | 0.80 | 1.15 | 1.38 | 0.56 | 9.62 | 164 | 3.25 |
| | | SLD125670 | | | 11 | 11.5 | 0.31 | 0.32 | 1.86 | 0.84 | 1.48 | 2.16 | 0.98 | 15.00 | 287 | 5.73 |
| | | SLD129759 | | | 13 | 13.5 | -0.47 | 1.04 | 1.53 | 0.96 | 1.32 | 1.66 | 1.17 | 2.09 | 27.37 | 0.52 |
| Plant 6 | HTZ88929 | HTZ88929 | 10 | 10/20/2005 | 10 (approximate) sidewall samples | | 44.8 | 56.3 | 58.3 | 1.2 | 1.6 | 489.0 | 1.6 | 0.9 | 3.7 | 32.5 |
| | HTZ88930 | HTZ88930 | | | | | 3.9 | 3.1 | 20.2 | 0.9 | 0.7 | 72.6 | 0.8 | 0.4 | 2.7 | 4.7 |
| Plant 7N and BNSF RR (DT-12) | SLD93275 | SLD93275 | 11.5 | 02/15/06 | 11.5 | 12 | 153 | 170 | 117 | 2.56 | 2.56 | 10,180 | 2.56 | 1.68 | 48.7 | 679.59 |
| | SLD93276 | SLD93276 | | | 11 | 11.5 | 21.4 | 23.7 | 32.6 | 1.13 | 1.13 | 2,961 | 1.13 | 0.25 | 16.1 | 197.58 |
| | SLD93277 | SLD93277 | | | 12 | 12.5 | 76.9 | 102 | 44.7 | 0.76 | 0.76 | 4,533 | 0.76 | -0.06 | 13.4 | 302.31 |
| DT-2 Levee | SLD120945 | SLD120945 | 28 | 10/08/09 | 28 (approximate) sidewall samples | | 11.60 | 14.1 | 45.20 | 1.55 | 1.55 | 1,097 | 1.55 | 1.31 | 22.40 | 73.46 |
| | SLD120946 | SLD120946 | | | | | 6.93 | 7.12 | 35.30 | 1.19 | 1.19 | 738 | 1.19 | 1.15 | 18.90 | 49.44 |
| | SLD120947 | SLD120947 | | | | | 5.68 | 7.09 | 32.90 | 1.09 | 1.09 | 1,180 | 1.09 | 0.71 | 35.30 | 79.22 |
| | SLD120948 | SLD120948 | | | | | 0.57 | 0.695 | 4.35 | 0.89 | 0.887 | 47.3 | 0.89 | -0.02 | 3.82 | 3.07 |
| **RI Screening Level for Soil** | | | | | | | | | **15** | **15** | | **15** | **15** | | **50** | **1** |
| **Soil Background Value [c]** | | | | | | | **0.14** | **0.89** | **2.78** | **0.95** | **1.16** | **1.94** | **1.09** | **0.09** | **1.44** | **NA** |

[a] Depths are bgs and are not corrected for the asphalt/concrete cover.
[b] A portion of the sewer associated with boring location SLD124580 is being removed and remediated under the 1998 ROD.
[c] Mean soil BVs obtained from USACE (1999a) are presented and were used to calculate SOR$_N$ values for soil.
Shaded results exceed the RI screening levels.

## Table 4-7. Sewer Soil Data: Stations with Metal Potential Contaminant of Concern Concentrations Exceeding Remedial Investigation Screening Levels

| Area | Station Name | Sample Name | Approximate Depth [a] of Sewer (ft) | Start Depth [a] (ft) | End Depth [a] (ft) | Arsenic (mg/kg) | Cadmium (mg/kg) | Lead (mg/kg) |
|---|---|---|---|---|---|---|---|---|
| Plant 1 | SLD124540 | SLD124540 | 9 | 7 | 7.5 | ***94.8*** J | ***13.4*** | 777 J |
| | | SLD124540-1 | | 7 | 7.5 | ***130*** J | ***24.7*** | 1450 J |
| | | SLD124541 | | 9.5 | 10 | ***83.7*** J | ***33.8*** | 1130 J |
| | | SLD125650 | | 11.5 | 12 | 15.8 J | ***4*** | 238 J |
| | SLD124546 | SLD124546 | 16 | 13 | 13.5 | 5.1 | 1.1 | 15.4 |
| | | SLD124547 | | 15.5 | 16 | 5.2 | 1.2 | 17.5 |
| | | SLD125653 | | 17 | 17.5 | ***60.9*** | 2.7 | 15.8 |
| | SLD124548 | SLD124548 | 4-6 | 4 | 4.5 | 4.9 | ***211*** | 59.5 |
| | | SLD124549 | | 6 | 6.5 | 20.9 | ***1730*** | 292 |
| | SLD124554 | SLD124554 | 8 | 5.5 | 6 | 8 | 1 | 16.2 J |
| | | SLD124555 | | 6.5 | 7 | 3.7 | 0.67 U | 16.4 J |
| | | SLD125657 | | 8.5 | 9 | 6.2 | ***28.8*** | 38 J |
| | SLD124560 | SLD124560 | 15 | 13 | 13.5 | 8 | 1.1 | 88.2 J |
| | | SLD124561 | | 14 | 14.5 | 22.1 | ***5.6*** | 952 J |
| | | SLD125660 | | 16 | 16.5 | 15.6 | 0.66 U | 16.7 J |
| | SLD124570 | SLD124570 | 10 | 6 | 6.5 | 7.7 | 0.84 | 149 |
| | | SLD124571 | | 8 | 8.5 | ***41.9*** | 0.31 U | 1260 |
| | | SLD125665 | | 10 | 10.5 | 10 | 0.31 U | 18.3 |
| | SLD125521 | SLD124562 | 7.5 | 6.5 | 7 | ***31.8*** | ***28.9*** | 660 |
| | | SLD124563 | | 8.5 | 9 | 5.1 | 0.52 | 29.5 |
| Plant 2 | SLD124576 | SLD124576 | 3 | 2.5 | 3 | 2.5 | 0.66 U | 196 J |
| | | SLD124577 | | 3.5 | 4 | 0.4 U | 0.63 U | ***9930*** J |
| | | SLD125668 | | 5 | 5.5 | 0.38 U | 1.2 U | 12.8 |
| | SLD124580[d] | SLD124580 | 10 | 8 | 8.5 | 21.4 | ***4.2*** | 8.5 |
| | | SLD124581 | | 9.5 | 10 | 14.3 | 2.8 | 14.2 |
| | | SLD125670 | | 11 | 11.5 | 13.1 | 3.5 | 21.5 |
| | | SLD129759 | | 13 | 13.5 | ***67.5*** | ***11.1*** | 15.3 |
| Plant 6WH | SLD127572 | SLD127574 | 9 | 4 | 4.5 | 11 | 0.59 U | 111 |
| | | SLD127575 | | 6 | 6.5 | 4 | 0.63 U | ***3370*** |
| | | SLD127576 | | 8.5 | 9 | 3.9 U | 0.62 U | 61.9 |
| Plant 7N and DT-12 | SLD124586 | SLD124586 | 5 | 4 | 4.5 | 7.2 | ***17.2*** | 264 J |
| | | SLD124587 | | 5 | 5.5 | 4.2 U | ***8.1*** | 130 J |
| | | SLD125673 | | 7.5 | 8 | 3.9 U | 0.62 U | 51.4 J |
| **RI Screening Level for Soil[a]** | | | | | | **60** | **17** | **800** |
| **Soil Background Value [c]** | | | | | | **27.76** | **3.8** | **2,980** |

[a] Depths are below cover material and are not corrected for the asphalt/concrete cover.
[b] RI Screening levels for arsenic, cadmium, and lead in soil are based on the 1998 FS screening levels for these metals. Although there are additional metal PCOCs associated with the sewers, no other metals exceed the RI screening levels.
[c] The soil BV used for characterization of each metal was obtained from USACE (1999a) as the lesser of the 95% UTL and maximum detected background concentration.
[d] A portion of the sewer associated with boring location SLD124580 is being removed and remediated under the 1998 ROD.
Shaded results exceed the screening level. ***Bold-italicized*** results exceed the soil BV.
U: The sample was analyzed but the result was below the detection limit.
J: The associated value is an estimated quantity.

#### *4.7.2.4 Summary of Plant 1 Sewer Results*

The analytical data for sewer sediment samples collected from manholes and drains at the Plant 1 indicate that sewer sediment is not radiologically impacted. No radiological PCOCs are present in sediment at concentrations exceeding the risk-based screening level. Two metals, arsenic and cadmium, were detected above the sediment screening levels in Plant 1 sewer sediments (arsenic at eight manholes locations and cadmium at one manhole location). The sediment samples exceeding the arsenic and cadmium screening levels are further evaluated for potential risk as part of the BRA.

The analytical data for soil samples collected adjacent to Plant 1 sewers indicate that historical releases from a sewer line resulted in the radiological contamination of subsurface soil adjacent to a segment of a 15-in sewer line located east of former Building G, at boring location SLD124540 (Figure H-3). This sewer line is located approximately 9 to 10 ft bgs, and the contamination extends from approximately 7 to 12 ft bgs. Arsenic, cadmium, and lead concentrations which exceed corresponding screening levels are commingled with radiological contamination in the samples collected from 7 ft to 10 ft bgs at this boring location. The soil samples exceeding screening levels at this location are further evaluated for potential risk as part of the BRA.

No other soil sampling locations associated with the sewers at Plant 1 had concentrations that exceeded the radiological screening level. Soil samples from six other Plant 1 soil boring locations exceeded screening levels for the metals arsenic, cadmium, and/or lead. These soil samples are further evaluated for potential risk as part of the BRA.

### 4.7.3 Plant 2 Sewers

The sewer investigation at Plant 2 involved sediment sampling of 10 manholes/grate inlets and soil sampling in 5 soil borings adjacent to portions of the sewer system. The sediment and soil sampling locations for Plant 2 sewers are presented on Figure H-4. The sediment and soil samples were analyzed for the 9 radiological and 12 metal PCOCs as discussed in Section 2.1. This section presents a description of the Plant 2 sewer system and detailed information concerning the nature and extent of contamination based on the sediment and soil sampling results for Plant 2 sewers, followed by a summary of the results. The RI results indicate that soil samples collected adjacent to one sewer line at Plant 2 exceed the soil screening levels for the radiological PCOCs and arsenic. This sewer line is currently being remediated under the 1998 ROD and therefore is not retained for evaluation in the BRA.

#### *4.7.3.1 Description of Plant 2 Sewers*

Plant 2 was served by sewer lines potentially affected by MED/AEC wastes. From 1942 to 1946, Plant 2 was used for the batch production of uranium dioxide. The drawings of the 50-series buildings and their associated sewers show three discharge points: one on the northern side of the buildings, one on the southern side of the buildings, and one on the eastern side of the buildings, all of which flow into a 15-in-diameter VCP near the center of Plant 2 (Figure H-4). Wastewater in the 15-in VCP flowed north via gravity to MH-44. At MH-44, the wastewater flowed north into an 18-in VCP through Plant 1 and ultimately discharged into the 3- x 4-ft private brick sewer main along Salisbury Street.

During the early 1970s, the 18-in-diameter VCP (that was connected to the 3- x 4-ft private brick sewer main along Salisbury Street) was capped off and the commercial wastewater from Plant 2 was redirected to the pump station installed in Plant 1. The Plant 2 wastewater was then pumped through a 16-in-diameter force main to neutralization basins in the northwest corner of Plant 7.

This occurred after MED/AEC operations were discontinued. Sewer drawings from 1980 indicate that the 18-in sewer pipe running through the center of Plant 2 was plugged on the south side of MH-37, thus preventing wastewater from flowing south to the Destrehan Street sewer. Maps showing flow directions for this sewer line indicate flow was to the north and wastewater discharged to the Salisbury Street private brick sewer. During sewer repair operations, manholes MH-34, MH-35, and MH-40 were removed and/or replaced.

Figure H-4 identifies specific areas along the Plant 2 sewer lines that were noted on a 1985 drawing as having broken and cracked pipe, little or no mortar, loose brick, or leaking pipe joints (Mallinckrodt Chemical Works, Inc. 1985a). This figure also identifies the portions of the sewers within and surrounding the MED/AEC process areas (former Buildings 50, 51, 51A, 52, and 52A) removed during the excavation activities performed under the 1998 ROD. The 15-in sewer line from MH-34 to MH-44 and a portion of the 8-in sewer line located west of MH-34 were removed and replaced. The sewer lines were at depths of approximately 10 to 14 ft bgs. A portion of the 12-in sewer located north of the MED/AEC process areas, east of MH-49, is scheduled for future remediation under the 1998 ROD.

#### *4.7.3.2 Nature and Extent of Contamination at Plant 2 Sewers*

This section presents the results of the RI sampling of sediment from sewer manholes/grates and soil adjacent to the sewers at Plant 2.

**Sediment Sampling Results:** Based on the results of the manhole sampling conducted at Plant 2, no radiological PCOCs are present in sediment at concentrations exceeding the RI screening levels. Arsenic concentrations in four Plant 2 sediment samples exceed the sediment screening level for arsenic (1.6 mg/kg). However, arsenic concentrations did not exceed the sediment background value (11.8 mg/kg), indicating the concentrations of arsenic present at Plant 2 are typical of background levels. The sewer sediment results for each Plant 2 sampling location are shown in Tables J-3 (radiological PCOCs) and J-4 (metal PCOCs).

**Soil Sampling Results:** Table 4-6 presents the results that exceed the RI screening level for the radiological PCOCs for soil samples collected adjacent to sewers at Plant 2. Based on the RI sampling results, soil associated with one sewer line is impacted by radiological contamination. The $SOR_N$ values calculated for two soil samples, collected at depths of 9.5 to 10 and 11.0 to 11.5 ft bgs from boring SLD124580, exceed the radiological screening level. Soil samples that were collected above (8 to 8.5 ft bgs) and below (13 to 13.5 ft bgs) this depth interval did not exceed the radiological screening level. The boring is located near the portion of a 10-ft-deep, 12-in line that extends west to east, along the northern edge of former MED/AEC Buildings 50, 51, 51A, 52, and 52A. This sewer line was reported to be "in fair condition, several leaking pipe joints" in a 1985 Mallinckrodt drawing (Mallinckrodt Chemical Works, Inc. 1985a). Soil samples from a boring located near MH-50 at the western end of this sewer line (SLD124574) did not exceed the radiological screening level. This sewer is scheduled for future remediation under the 1998 ROD and so is no longer within the scope of the ISOU (Figure H-4). The radiological results for the sewer soil samples at Plant 2 are presented in Table J-7.

Based on the RI sampling results for soil samples collected from borings installed adjacent to the Plant 2 sewer lines, two Plant 2 soil boring locations exceed soil screening levels for the metal PCOCs, one for arsenic and one for lead. Arsenic is commingled with radiological PCOCs exceeding screening levels at soil boring location SLD124580. The arsenic concentration (67.5 mg/kg) in the soil sample collected between 13 to 13.5 ft bgs from SLD124580 exceeds its screening level (60 mg/kg). In addition, a soil sample collected from one Plant 2 sewer soil boring location exceeds the screening level for lead. This boring (SLD124576) is located adjacent to an approximately 3-ft deep, 8-in sewer line located at the southwestern corner of the 50-series building area. The lead concentration in the 3.5 to 4 ft bgs soil sample from SLD124576 was 9,930 mg/kg, which exceeds the RI screening level of 800 mg/kg. It was not commingled with radiological PCOCs. No other Plant 2 soil sample collected adjacent to sewer lines exceed screening levels for the metal PCOCs. A summary of the soil results that exceed screening levels for the metal PCOCs is provided in Table 4-7. A full list of the metal PCOC results for the soil samples collected adjacent to the Plant 2 sewers is presented in Table J-8.

#### *4.7.3.3 Summary of Plant 2 Sewer Results*

The analytical data for sewer sediment samples collected from manholes and surface grates at Plant 2 indicate that sewer sediment is not radiologically impacted. No radiological PCOCs are present in sediment at concentrations exceeding the RI screening levels. One metal PCOC, arsenic, was detected above its RI screening level (1.6 mg/kg) in four Plant 2 sewer sediment samples, but did not exceed the sediment background value (11.8 mg/kg). The four arsenic sediment results exceeding the screening value are further evaluated for potential risk in the BRA.

The RI sewer soil data indicate that historical releases from a 10-ft-deep, 12-in sewer line located along the northern edge of former MED/AEC Buildings 50, 51, 51A, 52, and 52A have resulted in concentrations of radiological PCOCs and arsenic exceeding screening levels in soil adjacent to the sewer. The sewer is scheduled for future remediation under the 1998 ROD and so is no longer within the scope of the ISOU. No other soil sampling locations associated with the sewers at Plant 2 have concentrations that exceed the RI screening levels for radionuclides. Soil samples from one other Plant 2 soil boring location (SLD124576) exceed the RI screening level for lead. The lead result exceeding the soil screening value is further evaluated for potential risk in the BRA.

### 4.7.4 Plant 6 Sewers (Hall Street)

Most of the Plant 6 sewers are being remediated under the 1998 ROD as part of the Accessible Soil OU. Only a small portion of these sewers required additional sampling during this RI. The sewers at Plant 6 that were included in the scope of the RI WP include the 18-in sewer that extended east to west beneath Hall Street at the western edge of Plant 6, and portions of the sewers located at the southern edge of Plant 6, beneath the northern ROW of Destrehan Street. However, remediation of the area beneath Destrehan Street, including sewers and surrounding soil, is no longer included within the scope of the ISOU because remediation of this area is being performed under the 1998 ROD.

The RI sewer sampling conducted for the Plant 6 sewers involved sediment sampling of three manholes/grate inlets and soil sampling in two soil borings adjacent to portions of the sewer system. The sediment and soil sampling locations for Plant 6 are presented on Figure H-5. The sediment and soil samples were analyzed for the 9 radiological and 12 metal PCOCs as discussed in Section 2.1. This section presents a description of the Plant 6 sewer system and detailed information concerning the nature and extent of contamination based on the sampling results for Plant 6 sewers, followed by a summary of the results. The sewer soil data for Plant 6 indicates that historical releases from a segment of an 18-in sewer line located beneath Hall Street, adjacent to the northwest corner of Plant 6, have resulted in MED/AEC-related contamination in adjacent subsurface soil.

#### *4.7.4.1 Description of Plant 6 Sewers*

Both MED/AEC wastes and wastes that originated from Mallinckrodt commercial work (C-T operations) were transported in sewer lines at Plant 6. The Plant 6 sewers discharged via gravity into two different mains: a 30-in public sewer main that extended along the southern ROW of Destrehan Street, and a 27-in VCP MSD sewer to the west that extended south-to-north along Hall Street (Figure H-5). The 30-in public sewer main was constructed as part of MED/AEC operations in 1946 and discharged directly into the Mississippi River. The 27-in VCP MSD sewer line discharged into the 4.5-ft brick public sewer main located along Salisbury Street.

The Plant 6 sewer system discharged into the two sewer mains at three separate locations

1) Drains from former Plant 6WH MED/AEC Buildings 102A, 112, and 112A discharged via gravity into MH-19 in the 30-in-diameter VCP sewer located on the southern ROW side of Destrehan Street.
2) Drains from the remaining MED/AEC buildings formerly at Plant 6WH discharged via gravity into an 18-in-diameter VCP west to a manhole (MH-68) located near the southeast corner of Plant 1 on the 27-in-diameter public VCP (MSD) sewer.
3) The Plant 6EH VCP sewer system serving former MED/AEC Buildings 115, 116, and 117 flowed via gravity into MH-8 on the 30-in-diameter VCP sewer located on the southern ROW side of Destrehan Street.

Buildings 116 and 117 in Plant 6EH were used to receive and store C-T feed materials and drummed unreacted ore (URO) waste. Building drains in these two buildings discharged to an 18-in VCP sewer line located outside the eastern edge of these buildings and into the 30-in VCP sewer pipe that ran west-to-east along the southern ROW of Destrehan Street. Buildings 116 and 117 were demolished in 1997 (USACE 1998d). The smaller sewers/drains immediately south of Building 117 were likely used for MED/AEC operations.

In 1961, during the demolition of some of the Plant 6 buildings, the sewers that served the demolished buildings were capped off 4 ft bgs and 5 ft outside the footprint of the buildings and left in place (Mallinckrodt Chemical Works, Inc. 1960). The existing sewer flowing to the west from Building 110 was capped off on the 12-in line. In 1973, the existing manholes on the sewer flowing west to the 27-in public (MSD) sewer were converted from standard manhole tops to grated inlets. Manholes 11, 13, 14, and 15 have been removed and/or replaced.

The majority of the sewers at Plant 6 were not included in the scope of the RI WP (USACE 2009a). Many of the abandoned building sewers and drains at Plant 6 that were used for MED/AEC operations were exposed during remediation activities conducted under the 1998 ROD (USACE 1998a). Selective sampling was performed to determine the need for removal and, if contamination was found in the surrounding soil, the lines were removed. The sewers under Building 101 have not yet been remediated. Building 101 is proposed for demolition, which will make the sewers beneath the building accessible for remediation and outside the scope of the ISOU.

Figure H-5 identifies portions of the sewers removed during the excavation activities performed under the 1998 ROD. It also identifies portions of the sewer line that are scheduled for future remediation under the 1998 ROD. During remediation activities in the northern part of Plant 6, the 15- and 18-in laterals that line the Hall Street ROW and an unnamed manhole located approximately 40 ft west of Building 101 were removed. The 18-in sewer line located on the eastern boundary of Plant 6 at a depth of 8 to 10 ft bgs was removed so that contaminated soil that existed to an estimated depth of 2 ft below the sewer could be removed. The sewer lines were replaced and reburied with clean soil. In addition, the 10-, 12-, and 14-in sewer laterals located east of former Building 115 were removed but not replaced. At Plant 6, excavation activities were conducted at a 6-in VCP located along the south side of a former building footing located south of the current Building 101. The pipe extended west-to-east across the length of the remedial excavation and exited the excavation sidewalls. During remediation, high levels of radioactive materials were reported within the pipe. The pipe and surrounding soil within the excavation limits were removed as part of the remediation and the pipe was cemented closed at the excavation sidewall exit points. Remediation work south of the Building 101 area also included the removal and replacement of a 13-ft-deep manhole.

#### *4.7.4.2 Nature and Extent of Contamination at Plant 6 Sewers*

This section presents the results of the RI sampling of sediment from sewer manholes/grates and soil adjacent to the sewers at Plant 6.

**Sediment Sampling Results:** Based on the results of the manhole sampling at Plant 6, no radiological PCOCs are present in sediment over RI screening levels. $SOR_N$ values ranged from 0.01 to 0.14. Arsenic concentrations in two sediment samples from Plant 6 manholes exceed the arsenic screening level (1.6 mg/kg) but do not exceed the sediment background value for arsenic (11.8 mg/kg), indicating the concentrations of arsenic present at Plant 6 sediment are typical of background levels. The maximum arsenic concentration detected in Plant 6 sediment samples was 2.6 mg/kg, collected at station SLD123748, located near Hall Street. The other sample exceeding the arsenic screening value (SLD123746) is located along a portion of the sewer line that will be remediated under the 1998 ROD and so is no longer within the scope of the ISOU. The arsenic was not commingled with radiological PCOCs at either location. The sewer sediment results for the radiological and metal PCOCs at Plant 6 are provided in Tables J-3 and J-4, respectively.

**Soil Sampling Results:** The radiological results for the two soil borings drilled adjacent to the Plant 6 sewers during the RI are presented in Table J-9. One soil boring (SLD124572) was drilled adjacent to the 18-in sewer that runs beneath Hall Street and the other boring (SLD127572) was drilled adjacent to the sewer line located beneath the northern ROW of Destrehan Street. Concentrations of the radiological PCOCs in soil samples collected from these two boring locations do not exceed the RI screening levels. The $SOR_N$ values range from 0.001 to 0.26. The sewer beneath the northern ROW of Destrehan Street is being addressed under the 1998 ROD and is no longer within the scope of the ISOU.

In addition to the RI sampling data, two previous soil samples are included in the Plant 6 dataset. The two soil samples were collected in October 2005, during remediation activities conducted in the northwest corner of Plant 6WH. The remediation efforts included removal of portions of the 15 and 18-in sewer lines located between Hall Street and an unnamed manhole located approximately 40 ft west of Building 101. The portion of the sewer line extending under Hall Street was not made available for remediation and, therefore, is included in the scope of the ISOU. The two soil samples, HTZ88929 and HTZ88930, were collected from the soil around the portion of the sewer beneath Hall Street. Concentrations of the radiological PCOCs in soil samples collected from these two boring locations exceeded the RI screening levels. The $SOR_N$ values range from 4.7 to 32.5. The results are presented in Table J-9 and locations are shown on Figure H-5.

One sample from a Plant 6 soil boring location exceeds the screening level for lead (800 mg/kg). The maximum lead concentration, 3,370 mg/kg, was detected in the 6.0- to 6.5-ft bgs sample from boring SLD127572, located adjacent to the Hall Street sewer line. The vertical extent of lead contamination is defined by samples collected above (4 to 4.5 ft bgs) and below (8.5 to 9 ft bgs) this interval that did not exceed the lead screening levels. Lead is not commingled with radiological PCOCs at this location. None of the Plant 6 soil samples exceeded screening levels for the remaining metal PCOCs. The metal PCOC results for the soil samples collected adjacent to the Plant 6 sewers are presented in Table J-10.

#### *4.7.4.3 Summary of Plant 6 Sewer Results*

The analytical data for sewer sediment samples collected at Plant 6 indicate no radiological PCOCs are present in sediment at concentrations exceeding the risk-based screening levels. Only one metal PCOC, arsenic, was detected above its RI screening level. Arsenic exceeds the RI sediment screening level (1.6 mg/kg) in two Plant 6 sewer sediment samples, but does not exceed the sediment background value (11.8 mg/kg). One of the sediment samples exceeding the arsenic screening value (SLD123746) was collected in a manhole located along a portion of the sewer line that will be remediated under the 1998 ROD and so is no longer within the scope of the ISOU. The remaining sediment sample exceeding the arsenic screening level is further evaluated for potential risk in the BRA.

The radiological results for the two soil borings installed adjacent to the Plant 6 sewers during the RI do not exceed the RI soil screening levels. However, results of previous sampling conducted under the 1998 ROD during remediation of a sewer in the northwestern corner of Plant 6WH indicate that radiological contamination is present adjacent to the portion of this sewer line that extends beneath Hall Street. The soil data for the radiological PCOCs associated with the Hall Street sewer is further evaluated in the BRA.

The lead concentration in a soil sample from one Plant 6WH soil boring location exceeds the RI screening level. Lead is not commingled with radiological PCOCs at this location. No other soil sampling locations associated with the sewers at Plant 6 had concentrations that exceeded the RI screening levels for metals. The soil sample exceeding the lead screening value is further evaluated for potential risk in the BRA.

### 4.7.5 Plant 7N and Burlington-Northern Santa Fe Railroad (DT-12) Sewers

The majority of the MED/AEC sewers at Plant 7N were previously remediated under the 1998 ROD. Only a few sewers required additional sampling during this RI. One Plant 7N sewer that was originally included in the scope of the RI WP is the sewer line located southeast of MH-18, beneath the Hazardous Waste Storage Area. In 2010, the Hazardous Waste Storage Area was demolished. Because the sewer beneath this building became accessible, it was remediated as part of the 1998 ROD and is no longer within the scope of the ISOU. The remaining sewers in the Plant 7N area that were included in the scope of the RI WP are located beneath an adjacent road and RR. They include a portion of the 12-in sewer originating from the northeast corner of the Building 705/706 area and extending east to an unnamed manhole on Wharf Street and portions of two sewers extending eastward from Wharf Street to the BNSF RR (DT-12).

The RI sewer sampling conducted for the Plant 7N and DT-12 sewers involved sediment sampling of one manhole and soil sampling in one soil boring located adjacent to a portion of the sewer system. The sediment and soil sampling locations for Plant 7N and DT-12 are presented on Figure H-6. The sediment and soil samples were analyzed for the 9 radiological and 12 metal PCOCs as discussed in Section 2.1. In addition to the RI sampling data, three previous soil samples, collected in February 2006 during remediation activities conducted along the south side of Destrehan Street, are currently included in the Plant 7N and DT-12 dataset to support evaluation of the inaccessible portion of a 30-in sewer line underlying the BNSF RR line. When results become available, these 3 previous samples will be replaced with sampling data collected in Fall 2011 in areas in closer proximity to the portion of the 30-in sewer beneath the RR line.

This section presents a description of the Plant 7N sewer system and detailed information concerning the nature and extent of contamination based on the sampling results for Plant 7N sewers, followed by a summary of the results. The available data indicate that soil adjacent to the remaining portion of the 30-in Destrehan Street sewer that extends beneath the BNSF RR tracks (DT-12) may contain concentrations of radiological PCOCs that exceed screening levels.

#### *4.7.5.1 Description of Plant 7N and DT-12 Sewers*

Sewers at Plant 7N transported MED/AEC wastes as well as wastes that originated from Mallinckrodt commercial operations. During the MED/AEC operations conducted at Plant 7N, hydrofluoric acid waste stream from green salt ($UF_4$) processing was neutralized and discharged to the sewers (Mallinckrodt Group, Inc. 1994). The sewers serving Plant 7 tied into the 15-in VCP extending west to east along the northern ROW of Destrehan Street (Figure H-6). This 15-in sewer was constructed as part of MED/AEC operations in 1950 and discharged directly into the Mississippi River. Sewers serving commercial operations include those from Buildings 700, 704, 705, and 706, which were used for the storage of C-T ores and URO, and Buildings 700 and 708, which were used for the storage of tin slag feed material (Mallinckrodt Group, Inc. 2002). URO discharged to the sewers at Plant 5 flowed eastward into the 30-in sewer at the northern edge of Plant 7.

During the early 1970s, two wastewater neutralization basins were installed in the northwest corner of Plant 7W for pre-treatment of the commercial wastewater from Plants 1, 2, and 5. This construction included the installation of a pump station and a 16-in force main to convey the wastewater requiring neutralization from Plants 1, 2, and 5 to the basins in Plant 7W. The neutralization basins discharged into the 30-in sewer on the southern ROW of Destrehan Street. The wastewater ultimately discharged into the Mississippi River until the early 1970s when the sewers were routed via the Salisbury Street pump station to a 102-in sewer interceptor ultimately discharging to the Bissell Point Treatment Plant.

The majority of the abandoned building sewers at Plant 7N that were used for MED/AEC operations were exposed during excavation activities and have been removed. At Plant 7N, the portion of the 30-in sewer line extending along Destrehan Street from MH-19 to the DT-12 property line was removed and replaced. The soil surrounding the sewer line was also removed and replaced with clean soil to a depth of 10 to 12 ft bgs. The sewer lines in the vicinity of former Buildings 705, 706, and 707 were removed, but not replaced, during remediation activities at Plant 7N. Figure H-6 identifies the portions of the sewers removed at Plant 7N and DT-12 during the excavation activities performed under the 1998 ROD.

#### *4.7.5.2 Nature and Extent of Contamination at Plant 7N and DT-12 Sewers*

This section presents the results of the RI sampling of sediment from sewer manholes and soil adjacent to the sewers at Plant 7N.

**Sediment Sampling Results:** One sediment sample was collected for the Plant 7N and BNSF RR sewers. Sample SLD123745 was collected in a surface drain (grate inlet) located at the western edge of the former location of the Hazardous Waste Storage Area (Figure H-6) at Plant 7N. No radiological or metal PCOCs were detected in sediment at concentrations over their RI screening levels. The sediment sampling location is shown on Figure H-6.

**Soil Sampling Results:** The RI sewer sampling conducted for the Plant 7N and BNSF RR (DT-12) sewers involved soil sampling in one soil boring (SLD124586) located adjacent to the eastern end of the 12-in sewer that extends from the northeast corner of the Building 705/706 area northeastward to the unnamed manhole on Wharf Street. The boring is also located adjacent to the western end of a 15-in sewer line that runs beneath the BNSF RR line. Soil sampling was not conducted adjacent to the portion of the 15-inch sewer line extending beneath the RR line due to access restrictions. It was assumed that contaminant concentrations in SLD124586 would be representative of the portion of the 15-in sewer that runs beneath the RR line. No samples from this boring have concentrations that exceed the RI screening levels for radionuclides. $SOR_N$ values ranged from 0.01 to 0.42. One soil sample collected from a depth of 4 to 4.5 ft bgs has a cadmium concentration of 17.2 mg/kg. This value slightly exceeds the screening level for cadmium (17 mg/kg). Cadmium is not commingled with radiological PCOCs in this boring. None of the Plant 7N or BNSF RR soil samples exceed screening levels for the remaining metal PCOCs. The soil sampling locations are shown on Figure H-6. Figure H-6 also identifies portions of the sewers that have been or will be remediated under the 1998 ROD.

Soil sampling was not conducted adjacent to the portion of the 30-inch sewer line extending beneath the RR line due to access restrictions. For this reason, the Plant 7N/BNSF RR dataset currently includes soil data collected in February 2006, during remediation activities conducted along the south side of Destrehan Street (Shaw 2010). The 2006 remediation efforts included removal and replacement of most of the 30-in sewer located along the south side of Destrehan Street between MH-19 and MH-6. The 2006 data consists of three soil samples (SLD93275, SLD93276, and SLD93277) that were collected from the contact between the remaining portions of the 30-in sewer line that extend under the BNSF RR (DT-12) and the surrounding soil at a depth of approximately 12 ft bgs. For the purposes of the current evaluation, it was assumed that contaminant concentrations in these soil samples would be representative of the portion of the 30-in sewer that runs beneath the RR line. The soil samples were analyzed for the radiological PCOCs, but no metals analysis was performed. The concentrations of radiological PCOCs in these soil samples resulted in $SOR_N$ values ranging from 198 to 680. Additional soil samples were collected in September 2011 during remediation activities being conducted under the 1998 ROD along an immediately adjacent portion of the 30-in sewer line, just west of the tracks. Future soil sampling is planned adjacent to the 30-in sewer line during remediation activities that are currently being conducted under the 1998 ROD in an area immediately east of the RR tracks. Because the recent samples are in closer proximity to inaccessible portion of the sewer line underlying the tracks than the 2006 samples, they will replace the 2006 soil data when their analytical results become available. At that time, the portion of the 30-in sewer beneath the BNSF RR line will be re-evaluated by comparing the recent sampling results to the RI screening levels for radiological and metal PCOCs.

During the 2006 remediation activities for the accessible portions of the 30-in sewer, it was observed that the portion of the sewer extending under DT-12 was placed within a 4- to 6-in thick concrete cradle (Shaw 2010). The radiological activity detected using a 2x2 NaI detector was more elevated within the 30-in sewer and at the contact between the sewer and the concrete than it was at the contact between the silty clay soil and the concrete. This data indicates that the portion of the 30-in sewer line that remains beneath the BNSF RR (DT-12) and the surrounding concrete cradle may contain concentrations of radiological PCOCs that exceed screening levels. However, the concrete cradle may have limited or prevented the migration of radiological COCs from the sewer into the surrounding soil.

The radiological and metal PCOC results for the Plant 7N and BNSF RR (DT-12) soil samples are presented in Tables J-11 and J-12, respectively.

#### *4.7.5.3 Summary of Plant 7N and DT-12 Sewer Results*

The analytical data for the sewer sediment sample collected from a manhole at Plant 7N indicates that sewer sediment is not impacted by MED/AEC-related PCOCs. No radiological or metal PCOCs are present in sediment at concentrations exceeding the risk-based screening levels.

Based on the available data, soils adjacent to the 30-in sewer that runs along Destrehan Street likely contain concentrations of radiological PCOCs that exceed screening levels. As shown on Figure H-6, most of this Destrehan Street sewer line has been or will be remediated under the 1998 ROD. However, the portion beneath the BNSF RR (DT-12) has not been made accessible for remediation and so remains to be addressed as part of the ISOU. In addition, cadmium slightly exceeds its soil screening level at one boring location at the western end of a 15-in sewer line that runs beneath the BNSF RR. Based on these results, the portions of the 15-in and 30-in sewer lines that extend beneath the BNSF RR (DT-12) are further evaluated in the BRA.

### 4.7.6 Sewers Beneath the Mississippi River Levee at the St. Louis City Vicinity Property (DT-2)

No sampling of sewer sediment or soil adjacent to sewers was conducted for the DT-2 sewers as part of this RI. However, soil samples collected from the sidewalls of a sewer excavation during remediation conducted at DT-2 in 2009 has provided radiological data for this RI. The soil sampling locations for DT-2 are presented on Figure H-6. The soil samples were analyzed for the 9 radiological PCOCs as discussed in Section 2.1. The soil data for the sewers at DT-2 indicate that historical releases from segments of two sewer lines that run beneath the levee have resulted in MED/AEC-related contamination in adjacent subsurface soil.

#### *4.7.6.1 Description of DT-2 Sewers*

DT-2 is primarily undeveloped land that includes part of the Mississippi River Flood Protection Levee and the St. Louis Riverfront Trail (Figure 1-2). The portion of DT-2 addressed by the sewer investigation includes the levee area overlying the two Destrehan Street sewer lines. The sewer lines underlying the levee include both a 30- and a 15-in VCP sewer line that run from west to east adjacent to Destrehan Street and terminate at outfalls located at the edge of the Mississippi River. In October 2009, remediation was conducted in accordance with the 1998 ROD at DT-2 between the BNSF RR (DT-12) and the levee, which resulted in the removal of portions of the 15- and 30-in sewers sewer lines. Two inaccessible portions of these sewers remain. The segments under the BNSF RR (DT-12) are grouped with Plant 7N as discussed in Section 4.7.5. The segments under the levee on DT-2 are discussed in this section. The portions of these sewer lines that lie east of the levee have not yet been removed but are scheduled for future remediation under the 1998 ROD.

Prior to the 1970s, effluent from the Mallinckrodt Plant was discharged through the two sewers directly to the river, without treatment. According to information obtained from MSD, the portions of the sewer lines from the gate well located near Wharf Street to the outlets located at the river's edge are no longer in use (Shaw 2009).

The levee was constructed on DT-2 sometime between 1958 and 1962. The levee is oriented north to south, parallel to the river, and is constructed of a system of concrete floodwalls abutted to earthen levee structures. Based on available soil boring logs for nearby borings, both of the sewer lines underlying the levee appear to have been installed within non-engineered artificial fill material.

#### *4.7.6.2 Nature and Extent of Contamination at DT-2 Sewers*

This section presents a summary of the nature and extent of contamination of the sewers at DT-2.

**Sediment Sampling Results:** No sediment sampling of sewer manholes was conducted for the sewers beneath the levee at DT-2. Historical sediment data was available for two manholes, one along the 30-in sewer line and one along the 15-in sewer line. Radiological contamination was identified in the historical sediment sample collected from a manhole (MH-2) located along the 15-in sewer line.

**Soil Sampling Results:** The dataset for soil associated with the sewer line underlying the levee at DT-2 includes four sidewall samples collected in October 2009 during the remediation addressing the accessible portions of the sewers at DT-2. The four sampling locations (SLD120945 through SLD120948) are shown on Figure H-6. These samples were collected from the sidewalls of the excavation at approximately 28 ft bgs, adjacent to the 30-in sewer line. The analytical results from these four samples were significantly higher than the RI screening levels, with $SOR_N$ values ranging from 3.1 to 79.2. The primary PCOC contributing to the radiological contamination is Th-230. Concentrations of Th-230 range from 47.3 to 1,180 pCi/g. The radiological PCOC results for these four soil samples are presented in Table J-13. No metals data are available for these locations.

Additional information concerning the nature and extent of contamination is provided by the results of PDI sampling conducted along the nearby portions of both sewer lines (Shaw 2009). Based on the results of the PDI conducted at DT-2, radiological contamination near the levee appears to extend to a depth of approximately 38 ft bgs along the 15-in sewer and approximately 32 ft bgs along the 30-in sewer (Shaw 2009). The horizontal extent of radiological contamination generally appears to extend approximately 10 ft off of the centerline of the 15-in sewer line and approximately 20 ft off of the centerline of the 30-in sewer line. Radiological contamination was identified within the non-engineered artificial fill material that surrounded the sewers.

#### *4.7.6.3 Summary of DT-2 Sewer Results*

The available data indicate that soils adjacent to the 15-in and 30-in sewer lines that run beneath the levee contain concentrations of radiological PCOCs that exceed screening levels. As shown on Figure H-6, accessible portions of these sewer lines have been or will be remediated under the 1998 ROD. However, the portions of the sewers that run beneath the levee at DT-2 are not accessible for remediation and so remain to be addressed as part of the ISOU. The soil samples associated with these two sewers are further evaluated in the BRA.

### 4.7.7 PSC Metals, Inc. Vicinity Property (DT-8) and Illinois Department of Transportation and Missouri Department of Transportation Vicinity Property (DT-11) Sewers

The sewer investigation at DT-8 and DT-11 involved sediment sampling of one manhole/grate inlet and soil sampling in three soil borings located adjacent to portions of the two west-to-east-trending Salisbury Street sewer lines. The sediment and soil sampling locations for DT-8 and DT-11 are presented on Figure H-7. The sediment and soil samples were analyzed for the 9 radiological and 12 metal PCOCs as discussed in Section 2.1. This section presents a description of the DT-8 and DT-11 sewer system and information concerning the nature and extent of contamination based on the RI sampling results, followed by a summary of the results. The RI data indicates that only one metal, arsenic, exceeded the screening level in sediment, but it did not exceed the sediment background value and was not commingled with radiological PCOCs. No radiological or metal PCOCs exceeded the RI screening levels in DT-8 and DT-11 soil samples collected adjacent to the sewers.

#### *4.7.7.1 Description of DT-8 and DT-11 Sewers*

The PSC Metals, Inc. VP (DT-8) and the Illinois Department of Transportation and Missouri Department of Transportation VP (DT-11) are located between the Mallinckrodt Plant area and the Mississippi River (Figure H-7). Although MED/AEC-related activities were not conducted at these VPs, the sewers on these properties may have been impacted by historical discharges from the Mallinckrodt facility (Plants 1 and 6) located upstream. Two parallel sewer lines (one private and one public) extended west to east along Salisbury Street beneath these VPs and discharged directly into the Mississippi River. Mallinckrodt owned and operated the 3- x 4-ft brick private sewer, which was constructed sometime prior to initiation of MED/AEC activities. MSD owns and maintains the 4.5-ft-diameter brick public sewer. The public sewer runs parallel to, and slightly north of, the private sewer and is also several feet higher in elevation than the private sewer. It was constructed sometime prior to 1927 and is still in operation. In the 1970s, the private sewer collapsed and was abandoned, and the plant began discharging to the public sewer.

Two additional sewers are present beneath the eastern tract of DT-8. The sewer extending from an unnamed manhole on the BNSF RR (DT-12) through MH-1 to the 42-in diversion sewer was included in the scope of the ISOU. The 42-in diversion sewer was not included in the scope of the RI because it was built after MED/AEC activities ceased.

#### *4.7.7.2 Nature and Extent of Contamination at DT-8 and DT-11 Sewers*

This section presents the results of the RI sampling of sediment from sewer manholes/grates and soil adjacent to the sewers at DT-8 and DT-11.

**Sediment Sampling Results:** No sediment sampling was conducted for the Salisbury Street sewers located in DT-8 and DT-11. The three sediment sampling locations proposed in the RI WP were not sampled due to lack of sediment (two locations) or access problems (one location). One sediment sample (SLD123488) was collected in MH-1, located along the small sewer line that crosses the 42-in diversion sewer on the eastern tract of DT-11. No radiological PCOCs were detected at concentrations exceeding their screening levels in this sample. The arsenic concentration at SLD123488 (3.9 mg/kg) exceeded the arsenic screening level (1.6 mg/kg) but did not exceed the sediment background value for arsenic (11.8 mg/kg). Arsenic is not commingled with radiological PCOCs at this location. The sewer sediment results for the radiological and metal PCOCs at DT-8 and DT-11 are provided in Tables J-3 and J-4, respectively.

**Soil Sampling Results:** Concentrations of the radiological and metal PCOCs in soil samples collected from the three boring locations (SLD124590, SLD124592, and SLD124594) adjacent to the sewers at DT-8 and DT-11 along Salisbury Street do not exceed the RI screening levels. The $SOR_N$ values were less than 0.02. The radiological and metal PCOC results for the soil samples collected adjacent to the Salisbury Street sewers at DT-8 and DT-11 are presented in Tables J-14 and J-15, respectively.

#### *4.7.7.3 Summary of DT-8 and DT-11 Sewer Results*

The analytical data for the sewer sediment sample collected at DT-11 indicate that no radiological PCOCs are present in sediment at concentrations exceeding the risk-based screening levels. Only one metal PCOC, arsenic, was detected above its RI screening level but it does not exceed the sediment background value (11.8 mg/kg). Arsenic was not commingled with radiological PCOCs in this sample. Arsenic in this sediment sample is evaluated for potential risk in the BRA.

The radiological and metal results for the three soil borings located adjacent to the sewers at DT-8 and DT-11 along Salisbury Street do not exceed the RI screening levels. Therefore, no risk evaluation is conducted in the BRA for the radiological and metal PCOCs in DT-8 and DT-11 soil samples collected adjacent to the sewers.

## 4.8 SUMMARY OF NATURE AND EXTENT OF CONTAMINATION AND IDENTIFICATION OF CONSTITUENTS OF POTENTIAL CONCERN

This section summarizes the nature and extent of contamination for three categories of ISOU media:

- Inaccessible Soil Areas: soil that is inaccessible due to the presence of buildings or other permanent structures, the levee, active RRs, and roadways.
- Buildings and Structures: soil attached as residual material on the exteriors and interiors of buildings and other permanent structures.
- Sewers: sediment from manholes and surface drains (grate inlets) and soil adjacent to the sewer lines.

In addition, this section identifies those PCOCs that exceed the RI screening levels and are therefore retained as COPCs that are further evaluated in the BRA.

### 4.8.1 Summary of Nature and Extent of Contamination in Inaccessible Soil

An evaluation of the nature and extent of contamination was conducted for each of the three media categories on a property-by-property basis. Specific locations at each plant or VP where concentrations exceed the RI screening levels for radiological or metal PCOCs are briefly summarized below. The areas exceeding the PCOC screening levels are identified Table 4-8.

#### *4.8.1.1 Summary of Nature and Extent of Contamination in Inaccessible Soil Areas*

The following paragraphs summarize the nature and extent of contamination in inaccessible soil areas associated with (1) buildings and other permanent structures, (2) the levee, (3) RRs, and (4) roadways.

#### *4.8.1.2 Inaccessible Soil Areas Associated with Buildings and Other Permanent Structures*

The inaccessible soil areas beneath or adjacent to buildings and other permanent structures in the Mallinckrodt Plant areas that exceed the radiological screening level include:

- Plant 1: three areas adjacent to the Building K excavation, four areas associated with Building 8, a small area beneath Building 25, an area beneath Building 26, a small area north of the Southeast Containment Pad, a small area south of the loading dock south of Building X, and two areas beneath Building X.

- Plant 2: an area at Building 508, one area at the northwest end of the 50-series building excavation, a small area south of the 50-series building excavation (north of Building 510), and an area in the southeast corner of Plant 2.
- Plant 6: an area in the southwest corner adjacent to Destrehan St.

The inaccessible soil areas beneath or adjacent to buildings and other permanent structures at the SLDS VPs that exceed radiological screening level include:

- Gunther Salt (DT-4) North: areas within and adjacent to the Administration/Warehouse Building, sidewalk along Buchanan Street, salt domes area, and in two areas beneath the southern storage building.
- Heintz Steel (DT-6): areas beneath the Storage Building and areas on the western edge of the Storage Building along Hall Street.
- PSC Metals, Inc. (DT-8): an area of the RR tracks in North Tract 3 and an area in the southeast corner of the warehouse located in the South Tract.

Metal PCOCs were not detected above screening levels in inaccessible soil areas within the Mallinckrodt Plant areas that are inside the uranium-ore processing area (Plants 2, 6, and 7). One metal, arsenic, was found above the soil screening level in inaccessible soil samples collected at one VP within the uranium-ore processing area: Thomas and Proetz Lumber Company (DT-10).

#### *4.8.1.3 Inaccessible Soil Areas Associated with the Levee*

Radiological PCOCs were detected above the screening levels in samples collected from one area in the southern portion and one area in the central portion of the St. Louis Riverfront Levee at DT-2. The radiological contamination was found at depths less than 8 ft. DT-2 is not located within the uranium-ore processing area; therefore, only the radiological PCOCs are applicable to the inaccessible soil at this property.

#### *4.8.1.4 Inaccessible Soil Areas Associated with the Railroads*

Radiological PCOCs exceeding the screening level were found at the following RR VPs:

- Norfolk Southern RR VP (DT-3): one area east of Plant 3 and one area east of Plant 10.
- Terminal RR Association VP (DT-9): three areas on the Main Line between the McKinley Bridge and Destrehan Street and three areas in the Rail Yard (two on the northern RR track and one on the RR track traversing southwest to northeast).
- Terminal RR Soil Spoils Area: a small area at the southern end of the Norfolk Southern RR spur in the northern portion of the property, and two isolated areas along the Terminal RR tracks.
- BNSF RR VP (DT-12): one area located north of the McKinley Bridge east of DT-9 and a large area on the west side of the tracks extending from just north of Destrehan Street south to Dock Street.

Metal PCOCs exceeding screening levels within the uranium ore processing area were found at the following RR VPs:

- Terminal RR Association VP (DT-9): Cadmium was detected above the soil screening level at one location along the Terminal RR main line (DT-9) west of Plant 6.

- BNSF RR VP (DT-12): Arsenic was detected above the soil screening level at 10 locations along DT-12 between Destrehan and Angelrodt Streets. Seven of these locations were commingled with radiological contamination.

#### 4.8.1.5 *Inaccessible Soil Areas Associated with the Roadways*

Roads located outside of the Mallinckrodt Plant areas were not radiologically contaminated. Radiological PCOCs were detected above the screening level at individual locations along roads within or adjacent to the Mallinckrodt Plant area, including Hall Street, North Second Street, Mallinckrodt Street, Destrehan Street, and Angelrodt Street:

- Hall Street: two small areas at the property boundaries of Plant 6 and DT-6.
- North Second Street: an area located west of Building L at Plant 1.
- Mallinckrodt Street: three small isolated areas located north of Plant 2 Buildings 509, 507, and 502.
- Destrehan Street: two isolated areas located between North Broadway and Hall Street.
- Angelrodt Street: one area located south of Plant 7S.

Radiological contamination was also identified in areas along Destrehan Street east of Hall Street and adjacent to Plants 6 and 7. However, this portion of Destrehan Street will be remediated under the 1998 ROD.

Metal PCOCs were not detected above screening levels in soil samples collected from beneath roads within the uranium-ore processing area.

### 4.8.2 Summary of Nature and Extent of Contamination on Buildings and Structures

Buildings and structures such as, but not limited to, tanks, containment pads, loading docks, walkways, stairways, piping, pipe rack supports, electrical substations, fire hydrants, utility poles, street signs, and RR signs, were included in the scoping surveys. The results of the scoping surveys, as well as existing data, were used to evaluate the extent of radiological contamination. The scoping surveys consisted of scanning for alpha and beta surface activity and fixed-point measurements for total alpha and beta activity. The scoping surveys were biased, focusing on areas that are prone to accumulate contamination such as horizontal surfaces, depressions, cracked surfaces, rusted or unpainted surfaces, intake and exhaust vents, etc. While in the field, professional judgment also was used to select biased survey locations. There were over 4,600 fixed-point measurements obtained during the RI.

The following areas exceed the RI screening levels based on the results of the building and structure surveys:

- Plant 1: a small area, less than 1 $m^2$, on the south exterior wall of Building 25 just above ground level.
- Thomas and Proetz Lumber (DT-10): copper flashing above several sliding doors and the glass panels of four skylights of the Wood Storage Building.
- Cotto-Waxo (DT-14): a horizontal metal beam going from the L-shaped building to the brick warehouse.

The areas where surface activity measurements exceed the screening level in Plant 1, DT-10, and DT-14 are shown on Figures G-1, G-2 through G-7, and G-8, respectively.

### 4.8.3 Summary of Nature and Extent of Contamination Associated with Sewers

The following paragraphs briefly summarize the nature and extent of contamination in sewer sediment and soil adjacent to the sewers.

#### *4.8.3.1 Sewer Sediment*

Analytical data for sewer sediment samples collected from manholes and drains at the SLDS indicate that no radiological PCOCs are present in sediment at concentrations exceeding the screening level. Two of the 12 metal PCOCs identified for sewer sediment, arsenic and cadmium, were detected above screening levels. Sediment samples exceeded the arsenic screening level at eight Plant 1 locations, four Plant 2 locations, one Plant 6 location, and one location at DT-11. One sediment sample exceeded the cadmium screening level at Plant 1. Arsenic and cadmium were not commingled with radiological PCOCs.

#### *4.8.3.2 Soil Adjacent to Sewers*

Based on the RI results, soil samples collected adjacent to five sewer lines had concentrations of MED/AEC radionuclides exceeding the screening level. The results for these locations are as follows:

- Sampling results from a Plant 1 sewer soil boring indicate that historical releases from a damaged sewer line have resulted in the radiological contamination of subsurface soil, in exceedance of the screening level, adjacent to a segment of a 15-in sewer line located east of former Building G. This sewer line is located approximately 9 to 10 ft bgs, and the contamination extends from approximately 7 to 12 ft bgs. Arsenic, cadmium, and lead are present at concentrations which exceed their corresponding screening levels and are commingled with radiological contamination at this boring location.
- Radiological contamination was identified in subsurface soil adjacent to a 12-in sewer line located immediately north of the 50-series buildings soil excavation at Plant 2. The maximum $SOR_N$ value reported for this soil boring location (SLD124580) was 5.7. The investigation indicated the presence of commingled arsenic contamination in a soil sample collected adjacent to this sewer line. This sewer line is currently being remediated under the 1998 ROD and so it is not within the scope of the ISOU.
- Radiological contamination was identified in two subsurface soil samples (HTZ88929 and HTZ88930) collected adjacent to the sewer line that extends from Plant 6WH to beneath Hall Street. The maximum $SOR_N$ value reported for these two samples was 32.5. No metals data was available for these samples.
- Radiological contamination has been identified in soil surrounding a 30-in sewer line that runs west to east along the south side of Destrehan Street to the Mississippi River. The accessible portions of this sewer line have been or will be remediated under the 1998 ROD, but the portions extending under the BNSF RR (DT-12) and the levee (DT-2) are not accessible and so remain to be addressed under the ISOU. The maximum $SOR_N$ values reported for soil samples collected adjacent to the 30-in sewer line at the levee (DT-2) and the BNSF RR (DT-12) were 79.2 and 679.6, respectively. No metals data are currently available for these portions of the Destrehan Street sewers. Additional soil samples were collected in September 2011 adjacent to the Destrehan Street sewer near the portion of the sewers underlying the RR tracks at DT-12. Future soil sampling is planned adjacent to the 30-in sewer line in an area immediately east of the RR tracks as part of the remediation activities that are currently being conducted under the 1998 ROD.

When the results of this sampling become available, they will be used to evaluate if radiological and metal PCOCs are present above screening levels along the portion of the 30-in sewer line underlying the RR tracks.

The above results are limited to those soil borings adjacent to sewer lines that had radiological PCOCs above the screening level. In addition to the above results, arsenic, cadmium, and/or lead exceeded screening levels at nine soil borings located adjacent to sewer lines, but were not commingled with radiological PCOCs at these locations: arsenic, cadmium, and/or lead at six Plant 1 borings, lead in one Plant 2 boring, lead in one Plant 6WH boring, and cadmium in one Plant 7N/BNSF RR boring.

### 4.8.4 Contaminants of Potential Concern

The COPCs for inaccessible soil areas, buildings and structures, and sewers have been identified based on a comparison of the detected concentrations of the PCOCs to the RI screening levels (Table 4-8). The radiological and metal PCOCs that were detected during the RI at concentrations exceeding the RI screening levels have been designated as COPCs. The COPCs include all the radiological PCOCs for inaccessible soil areas, buildings, and soil adjacent to sewers, and the metals arsenic, cadmium and lead for inaccessible soil areas on RRs and soil adjacent to sewers. The COPCs have been carried forward in Section 5.0 for the discussion of contaminant fate and transport and are quantitatively evaluated in the BRA to determine human health carcinogenic and noncarcinogenic risks.

**Table 4-8. Summary of Nature and Extent of Contamination at the St. Louis Downtown Site Properties by Media**

| Property | Specific Location | ISOU Media | | | |
|---|---|---|---|---|---|
| | | Inaccessible Soil | Building/ Structural Surfaces | Sewers | |
| | | | | Sewer Sediment | Soil Adjacent to Sewer |
| Plant 1 | Building 25 | Radiological | Radiological | - | - |
| | Area Beneath Building 26 | Radiological | - | - | - |
| | Two Areas Beneath Building X | Radiological | - | - | - |
| | Four Areas at Building 8 | Radiological | - | - | - |
| | Three Inaccessible Soil Areas Adjacent to Building K Excavation Area | Radiological | - | - | - |
| | Inaccessible Soil Area North of Southeast Containment Pad | Radiological | - | - | - |
| | Inaccessible Soil Area South of Building X Loading Dock | Radiological | - | - | - |
| | Between Buildings G and 17 | - | - | - | Radiological, As, Cd, Pb |
| | Various Sewer Sediment Locations | - | - | As, Cd | - |
| | Various Sewer Borehole Locations | - | - | - | As, Cd, Pb |

## Table 4-8. Summary of Nature and Extent of Contamination at the St. Louis Downtown Site Properties by Media (Continued)

| Property | Specific Location | ISOU Media | | | |
|---|---|---|---|---|---|
| | | Inaccessible Soil | Building/ Structural Surfaces | Sewers | |
| | | | | Sewer Sediment | Soil Adjacent to Sewer |
| Plant 2 | Building 508 | Radiological | - | - | - |
| | Area at northwest end of 50-series Building Excavation | Radiological | | | |
| | Inaccessible Soil Area North of Building 510 (and South of the 50-Series Buildings Excavation). | Radiological | - | - | - |
| | Southeast Corner | Radiological | - | - | - |
| | Various Sewer Sediment Locations | - | - | As | - |
| | One Sewer Borehole Location | - | - | - | Pb |
| Plant 6 | Inaccessible Areas at the Southwest Corner Adjacent to Destrehan Street | Radiological | - | - | - |
| | Along Hall Street, West of Plant 6 | Radiological | - | - | |
| | Sewer Beneath Hall Street at Northwest Corner of Plant 6WH | - | - | - | Radiological |
| | Sewer Sediment Locations | - | - | As | - |
| | Soil Location South of Plant 6WH adjacent to Sewer Line | - | - | - | Pb |
| St. Louis City Property (DT-2) | Levee South Area (East of Adjacent Plant 7E and DT-1) | Radiological | - | - | - |
| | Levee Area South of the McKinley Bridge | Radiological | - | - | - |
| | Sewers Beneath the Levee | - | - | - | Radiological |
| Gunther Salt (DT-4) North | Salt Dome Area and Northeast Corner of Southern Storage Building | Radiological | - | - | - |
| | Southern Storage Building | Radiological | - | - | - |
| | Sidewalk along Buchanan Street | Radiological | | | |
| | Areas Within and Adjacent to Administration/Warehouse Building | Radiological | - | - | - |
| Heintz Steel (DT-6) | Areas Beneath Storage Building | Radiological | - | - | - |
| | Inaccessible Area at Western Edge of Storage Building Along Hall Street | Radiological | - | - | - |
| PSC Metals, Inc. (DT-8) | North Tract 3 – RR Tracks Area | Radiological | - | - | - |
| | North Tract 4 – RR Tracks Area | Radiological | - | - | - |
| | South Tract – Southeast Corner of Warehouse | Radiological | - | - | - |
| Thomas and Proetz Lumber Company (DT-10) | Office Building | As | - | - | - |
| | Wood Storage Building | - | Radiological | - | - |

## Table 4-8. Summary of Nature and Extent of Contamination at the St. Louis Downtown Site Properties by Media (Continued)

| Property | Specific Location | ISOU Media | | | |
|---|---|---|---|---|---|
| | | Inaccessible Soil | Building/ Structural Surfaces | Sewers | |
| | | | | Sewer Sediment | Soil Adjacent to Sewer |
| Illinois Department of Transportation and Missouri Department of Transportation (DT-11) | Sewer Sediment Location | - | - | As | - |
| Cotto-Waxo Company (DT-14) | A small area on a metal beam at roof level of the L-shaped Building | - | Radiological | - | - |
| Norfolk Southern RR (DT-3) | Area East of Plant 10 and South of Destrehan Street | Radiological | - | - | - |
| Terminal RR Association (DT-9) Rail Yard | Three Areas in the Rail Yard (Two on the Northern RR Track and One on the RR Track Traversing Southwest to Northeast) | Radiological | - | - | - |
| Terminal RR Association (DT-9) Main Tracks | Three Areas Between the McKinley Bridge and Destrehan Street | Radiological Cd | - | - | - |
| Terminal RR Soil Spoils Area | Small Area at the Southern End of the Norfolk Southern RR Spur in the Northern Portion of the Property, and Two Isolated Areas Along the Terminal RR Tracks | Radiological | - | - | - |
| BNSF RR (DT-12) | One Area North of the McKinley Bridge, East and adjacent to DT-9 Rail Yard | Radiological | - | - | - |
| | Large Area on the West side of Tracks Extending from Just North of Destrehan Street South to Dock Street | Radiological, As | - | - | - |
| | Sewers Northeast of Plant 7N Beneath BNSF RR tracks | - | - | - | Radiological, Cd |
| Hall Street | West of Plant 6 | Radiological | - | - | - |
| North Second Street | West of Plant 1 | Radiological | - | - | - |
| Mallinckrodt Street | North of Plant 2 | Radiological | - | - | - |
| Destrehan Street | West of Hall Street | Radiological | - | - | - |
| Angelrodt Street | South of Plant 7S | Radiological | - | - | - |

Note: Radiological COPCs were identified by exceedance of $SOR_N > 1.0$, and always include the following: Ac-227, Pa-231, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-235, and U-238. Metals were only identified as COPCs if they exceed the industrial risk-based screening level. Dashes indicate no COPCs are identified for the area and medium.
As – arsenic
Cd – cadmium
Pb – lead

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# 5.0 CONTAMINANT FATE AND TRANSPORT

The mobility and persistence characteristics of a contaminant in the environment are significant in determining the environmental fate and transport of that contaminant. Contaminant fate and transport is also dependent on the chemical and physical characteristics of the site and environmental medium in which the contaminant resides. Examples of chemical characteristics of the site/medium include pH in the soil and water, organic content of soil, oxidation-reduction potential (ORP), and the presence of inorganics (e.g., carbonates, sulfates, iron, etc.). Examples of physical characteristics include geological and hydrological parameters (e.g. hydraulic conductivity, porosity, hydraulic gradients, etc.), temperature, the presence of surface water bodies, buildings, ground cover, etc. Additionally, the presence or absence of oxygen and microbial organisms in the environmental medium could determine the persistence of certain contaminants, particularly organic contaminants. Although the degree of impact is uncertain because of the capacity of some contaminants to move from one medium to another or to become degraded by one or more biotic and/or abiotic processes, the analysis of contaminant fate and transport can be used to assess the potential rate of migration and fate of contaminants.

Understanding contaminant fate and transport provides information that can be used to support development of the CSM. During the RI, the CSM is used to identify the potentially complete human or environmental exposure pathways that form the basis of evaluations for the BRA. The CSM for the ISOU is presented schematically in Figure 5-1 and shows potential exposure pathways, under current and expected future land use scenarios, that are considered 1) complete and potentially significant, 2) potentially complete but insignificant, and 3) incomplete. Complete and potentially significant exposure pathways are retained for further quantitative evaluations in the BRA. A complete exposure pathway is comprised of each of the following elements:

- a source,
- a mechanism of contaminant release and transport process/medium (e.g., soil),
- an exposure medium and point where humans could contact the contaminated medium, and
- an exposure route (i.e., ingestion, dermal contact, inhalation, or external radiation).

ISOU sources (i.e., the first element above) are discussed in Section 5.1. The remaining three elements are discussed in Section 5.2, with a focus on contaminant release and transport mechanisms. Section 5.3 discusses the chemical and physical characteristics of contaminants and the environmental media that govern environmental fate and transport. Section 5.4 discusses the chemical and physical characteristics of COPCs and provides a means to assess which fate and transport processes are likely to be dominant under ISOU-specific conditions.

The CSM assumes that current and future land use for the SLDS is industrial/commercial in an urban setting. Exposure pathways are evaluated under the current configuration of contaminants existing in inaccessible soil areas (e.g., beneath or adjacent to buildings and structures), sewers and soil adjacent to sewers, and soil on building and structural surfaces. The CSM does not consider future scenarios in which the inaccessible soil areas become accessible due to removal of buildings, ground cover, etc., because this would result in conditions that would have to be addressed in accordance with the 1998 ROD (USACE 1998a), which considers only accessible media.

Another CSM has been developed in the BRA that identifies exposure pathways for both currently accessible and inaccessible soil. These pathways are evaluated in the BRA using exposure assumptions consistent with those being applied in the plant and VP PRARs and FSSEs being developed under the 1998 ROD (USACE 1998a). The objective of this approach is to assess the overall risk status for each property based on the incorporation of all available data and one consistent set of exposure scenarios across both OUs that will facilitate the strategy development and decision-making needed for preparation of the ISOU FS, Proposed Plan, and ROD.

## 5.1 INACCESSIBLE SOIL OPERABLE UNIT SOURCES OF CONTAMINATION

Historic contaminant sources at the SLDS include uranium ores and radioactive residues and wastes resulting from MED/AEC processing and waste handling, storage, and hauling activities. Previous remedial actions at the SLDS have removed all of the historic MED/AEC processing buildings except for Building 25 at Plant 1 and have remediated much of the radiologically contaminated accessible soil to levels that are protective of human health and the environment in accordance with the 1998 ROD (USACE 1998a).

Although the MED/AEC processing and waste handling activities that created the contaminant sources at the SLDS ceased in the 1950s, constituents present in the source areas may have migrated to other media still present at the site. These remaining media are identified as current contaminant and exposure sources in the ISOU per the CSM. A source material is defined by USEPA (1991c) as "material that includes or contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to ground water, to surface water, to air, or acts as a source for direct exposure." For the purposes of the CSM, a source is an environmental medium that has been directly impacted by former MED/AEC operations. The CSM (Figure 5-1) identifies three main categories of potential sources of contamination and exposure within the ISOU: inaccessible contaminated soil; radiologically contaminated particles (e.g., soil) on structural surfaces; and sewer sediment and soil adjacent to sewer lines. Inaccessible soil is further characterized as soil beneath or adjacent to buildings, the soil beneath or adjacent to the levee, soil beneath or adjacent to the RRs, and soil beneath or adjacent to roadways. Some soil areas adjacent to buildings, RRs, roadways, and the levee are beneath consolidated ground cover (e.g., pavement). Other soil areas adjacent to buildings, RRs, roadways, and the levee consist of soil that is either beneath unconsolidated ground cover (e.g., gravel) or is exposed to the environment due to the absence of any cover. The soil in these areas is considered to be inaccessible because remediation could not be conducted in accordance with the 1998 ROD (USACE 1998a) due to concerns of compromising the integrity of the adjacent building, RR, roadway, or levee.

### 5.1.1 Inaccessible Soil Associated with Buildings and Structures

There were no metals detected in soil beneath any SLDS buildings that exceed risk-based screening levels, indicating no potential for MED/AEC-related sources of metals contamination beneath buildings. Based on exceedances of radiological screening levels, potential MED/AEC-related radiological source areas of inaccessible soil beneath buildings are identified below by property and building, with the associated figure indicated in parentheses. These sources are represented in the source column of Figure 5-1 as "Inaccessible Soil Beneath Consolidated Ground Cover".

- Plant 1 (Figure C-1)
  - Building 26
  - Two Areas Beneath Building X
  - Two locations beneath Building 8

- Plant 2 (Figure C-2)
  - Building 508
- Gunther Salt (DT-4) North (Figure C-7)
  - Two areas beneath Southern Storage Building
  - Northern Salt Dome Building
  - Administration/Warehouse Building
- Heinz Steel (DT-6) (Figure C-8)
  - Storage Building
- PSC Metals (DT-8) (Figure C-9)
  - South Tract – Southeast Corner of Warehouse

Aside from those areas of inaccessible soil directly beneath buildings, there are also areas of soil located adjacent to buildings that exceeded radiological screening values but were not remediated under the 1998 ROD because of limited excavation access or for protection of the integrity of an adjacent structure(s). Of the metals samples collected in these inaccessible areas, only arsenic was detected above the risk-based screening level at three locations adjacent to the office building at DT-10. Potential MED/AEC-related radiological source areas of inaccessible soils located adjacent to buildings are identified below, with the associated figure indicated in parentheses. These sources are represented in the source column of Figure 5-1 as "Inaccessible Soil Beneath Consolidated Ground Cover" and "Inaccessible Soil Beneath Unconsolidated Cover or No Cover".

- Plant 1 (Figure C-1)
  - Two Inaccessible Soil Areas West of Building 8
  - Three Inaccessible Soil Areas Adjacent to Building K Excavation Area
  - Inaccessible Soil Area North of Southeast Containment Pad
  - Inaccessible Soil Area South of Building X Loading Dock
- Plant 2 (Figure C-2)
  - Inaccessible Soil Area at North End of the 50-Series Buildings Excavation
  - Inaccessible Soil Area North of Building 510 (and South of the 50-Series Building Excavation)
  - Inaccessible Soil Area at the Southeast Corner
- Plant 6 (Figure C-3)
  - Inaccessible Soil Area at the Southwest Corner Adjacent to Destrehan Street
- Gunther Salt (DT-4) North (Figure C-7)
  - Salt Dome Area and Northeast Corner of Southern Storage Building
  - Sidewalk Along Buchanan Street
  - Inaccessible Soil Area on Northern Side of the Administration/Warehouse Building
- Heinz Steel (DT-6) (Figure C-8)
  - Inaccessible Soil Area West of the Storage Building
- PSC Metals (DT-8) (Figure C-9)
  - North Tract 3 – RR Tracks Area

Of the above-listed areas that are not located directly beneath buildings, and based on the boring logs in Appendix A, the following are areas covered in gravel and lack any impermeable, consolidated ground cover (e.g., concrete or asphalt pavement). These sources are represented in the source column of Figure 5-1 as "Inaccessible Soil Beneath Unconsolidated Cover or No Cover".

- Plant 2 (Figure C-2)
  - Inaccessible Soil Area at the Southeast Corner
- Plant 6 (Figure C-3)
  - Inaccessible Soil Area at the Southwest Corner Adjacent to Destrehan Street
- Heinz Steel (DT-6) (Figure C-9)
  - Inaccessible Soil Area at Western Edge of Storage Building Along Hall Street
- PSC Metals (DT-8) (Figure C-10)
  - North Tract 3 – RR Tracks Area

Because these inaccessible soil areas are exposed to the environment, the contaminants contained therein are more subject to mechanisms that allow for release and transport in the surrounding environment than those areas that are either beneath buildings or consolidated material. The release and environmental transport mechanisms associated with all inaccessible soil areas located beneath or adjacent to buildings/structures are described in Section 5.2.2.

### 5.1.2 Inaccessible Soil Associated with the Levee

Several soil samples were collected from the St. Louis City Property (DT-2) as shown in Figure C-11 to characterize the inaccessible soil beneath the levee. Elevated radiological activity resulting in exceedances of screening levels were detected at two areas one south of the McKinley Bridge and the other on the east side of the levee directly east of Plant 7E and the Kiesel VP (DT-1). Depths of the exceedances range from 4.0 to approximately 8 ft bgs. Because of the presence of elevated radiological activities in the subsurface soil beneath the levee, these areas are considered to be potential sources in the CSM, which are represented in the source column of Figure 5-1 as "Inaccessible Soil Beneath Unconsolidated Cover or No Cover". Environmental release and transport mechanisms associated with these areas are discussed in Section 5.2.2. No radiological concentrations exceeding the screening level were detected on the surface of the levee.

### 5.1.3 Inaccessible Soil Associated with Railroads (Railroad Properties)

Isolated areas of radiological contamination were detected within the ballasted track area of the Norfolk Southern RR (DT-3) main line (adjacent to Plants 3 and 10, per Figures C-14 and C-15, respectively) and the Terminal RR (DT-9) main line (adjacent to Plants 1 and 2, per Figure C-16) and rail yard (Figure C-16) to a depth of approximately 2 ft. Radiological contamination was also found in the Terminal RR Soil Spoils Area (Figure C-18) to a depth of approximately 5.5 ft. Radiological contamination was also detected along the BNSF RR (DT-12) (east of the DT-9 rail yard, per Figure C-19, and from DT-4 to Plant 6, per Figure C-20) to a depth of almost 6 ft. Arsenic was also detected above the soil screening level in inaccessible soil samples collected at DT-12 that were commingled with radiological contamination at seven sampling locations between Destrehan and Angelrodt Streets in the uranium-ore processing area. Cadmium was detected above the risk-based screening level at Terminal RR DT-9 main line west of Plant 6.

Consequently, the above RR locations are identified as potential sources of radiological and metals contamination. These sources are represented in the source column of Figure 5-1 as "Inaccessible Soil Beneath Unconsolidated Cover or No Cover". Environmental release and transport mechanisms associated with these areas are discussed in Section 5.2.2.

### 5.1.4 Inaccessible Soil Associated with Roadways

Elevated areas of radiological activity were detected beneath several roadways as follows:

- Hall Street, at several locations between Plants 2 and 6, and at several locations adjacent to the DT-6 storage building (Figures C-8 and C-22),
- North Second Street, west of Plant 1 at one location (Figure C-21),
- Mallinckrodt Street, north of Plant 2 at three locations (Figure C-25),
- Destrehan Street, west of Hall Street at two locations (Figure C-26), and at
- Angelrodt Street, between Plant 7S and Midwest Waste (DT-7) (Figure C-26).

Consequently, the above locations are identified as potential sources of radiological contamination. These sources are represented in the source column of Figure 5-1 as "Inaccessible Soil Beneath Consolidated Ground Cover". Environmental release and transport mechanisms associated with these areas are discussed in Section 5.2.2. No metals concentrations exceeding screening levels were detected beneath the investigated roadways.

### 5.1.5 Soil on Buildings and Structures

Interior and exterior surfaces of buildings and permanent structures (identified in Table 4-5) were radiologically surveyed during the RI. The results of the surveys were compared to a structural surface DCGL derived for protection of the most limiting receptor, the industrial site worker. Isolated exceedances of the DCGL, not related to naturally occurring radioactive material (NORM), were observed on exterior surface and/or roof areas on five buildings, as summarized below (associated figures are indicated in parentheses):

- Plant 1
  - Building 25 – south exterior wall just above ground level (Figure G-1)
- Thomas and Proetz Lumber Company (DT-10)
  - Seven areas on copper flashing above rolling doors along north wall of the Wood Storage Building (Figure G-2)
  - One area on east side of the Wood Storage Building (Figure G-3)
  - Four areas on copper flashing above rolling doors on west side of the Wood Storage Building (Figure G-4)
  - The glass panels on each of four dog house-style skylights on roof of the Wood Storage Building (Figures G-5, G-6, and G-7)
- Cotto-Waxo Company (DT-14)
  - One area on a horizontal beam going from the L-shaped building to the brick warehouse (Figure G-8)

Because of the screening level exceedances, the above-listed areas on buildings/structures are identified as potential radiological sources for human exposures. These sources are represented in the source column of Figure 5-1 as "Structural Surfaces". Environmental release and transport mechanisms associated with these areas are discussed in Section 5.2.2.

### 5.1.6 Sewers

During the RI, sediment samples were collected from inside of sewer lines at Plants 1, 2, 6, 7, and from the Illinois Department of Transportation and Missouri Department of Transportation VP (DT-11). Subsequent sewer sediment data comparisons with radiological screening levels (see Section 4.7 and Appendix J Table J-3) resulted in all radiological $SOR_N$ values being less than 1.0 for each location sampled. Risk-based screening level comparisons with metals data, acquired for the same sediment locations sampled for radiological parameters, indicated arsenic and/or cadmium exceedances in sewer lines located at the following plant properties and sediment locations, as shown in Table 5-1.

**Table 5-1. Summary of Sediment Locations Exceeding Metals Screening Levels**

| Property | Sewer Sediment Location | Location Description | Sewer Sediment COPC |
|---|---|---|---|
| Plant 1 | SLD123489 | Manhole along Salisbury Street | Arsenic |
| | | | Cadmium |
| Plant 1 | SLD123490 | Surface drain north of Building 3 | Arsenic |
| Plant 1 | SLD123492 | Surface drain MH-56 | Arsenic |
| Plant 1 | SLD123493 | Surface drain MH-55 | Arsenic |
| Plant 1 | SLD123494 | Manhole MH-58 | Arsenic |
| Plant 1 | SLD123495 | Surface drain approx. 30 feet from the southwest corner of Building G | Arsenic |
| Plant 1 | SLD123496 | Surface drain in the center of Buildings B, C, 10, F, and G | Arsenic |
| Plant 1 | SLD123498 | Surface Drain MH-66 | Arsenic |
| Plant 2 | SLD123740 | Surface drain MH-51 west of former 50-series bldgs. | Arsenic |
| Plant 2 | SLD123743 | Manhole MH-37 | Arsenic |
| Plant 2 | SLD123744 | Manhole MH-39 south of plant along Destrehan Street | Arsenic |
| Plant 2 | SLD123749 | Surface drain north of Bldg. 502 | Arsenic |
| Plant 2 | SLD123750 | Curb drain outside of plant along North Second Street | Arsenic |
| Plant 6 | SLD123748 | Surface drain MH-30 along western plant boundary | Arsenic |
| DT-11 | SLD123488 | Manhole MH-1 just south of McKinley Bridge | Arsenic |

Historically, breaks and leaks in sewer lines may have resulted in releases of MED/AEC-related contamination to the inaccessible soils adjacent to the sewer lines. Therefore, during the RI, soil samples were collected adjacent to sewer lines, the data for which were subsequently compared to radiological and metals soil screening levels. Soil samples adjacent to the sewer lines were collected from Plants 1, 2, 6, 6E, 7N, BNSF RR (DT-12), St. Louis City VP (DT-2), PSC Metals, Inc. (DT-8), and the Illinois Department of Transportation and Missouri Department of Transportation VP (DT-11). Some of the samples were collected from excavations during sewer line removals (i.e., at Plant 6, Plant 7N/BNSF RR, and DT-2). Soil sampling locations adjacent to sewer lines exceeding the screening levels are summarized below:

- Plant 1 (located between Buildings G and 17, beneath asphalt and concrete, adjacent to active sewer line) (Figure H-3)
  - radiological contaminants
  - arsenic
  - cadmium
  - lead

- Plant 6 (sidewall samples from sewer excavation at northwest corner of property, beneath pavement, near inactive sewer line that runs beneath Hall Street) (Figure H-5),
  - radiological contaminants
- Plant 7N/BNSF RR (DT-12) (sidewall samples from sewer excavation northeast of Plant 7N, beneath RR line, near sewer line) (Figure H-6),
  - radiological contaminants
- St. Louis City Property (DT-2) (sidewall samples from sewer excavation near the levee; beneath unconsolidated cover; adjacent to inactive sewer line) (Figure H-7),
  - radiological contaminants

In addition to the above exceedances of screening levels, radiological contaminants and arsenic were detected above screening levels in a soil boring located adjacent to a 12-in sewer line located along the northern edge of former MED/AEC Buildings 50, 51, 51A, 52, and 52A at Plant 2. However, this sewer is scheduled for future remediation under the 1998 ROD and so is no longer within the scope of the ISOU.

Because of the screening level exceedances, the above-listed sewer sediment locations and areas of soil adjacent to sewer lines are identified as potential sources of metals and radiological contaminants. These sources are represented in the source column of Figure 5-1 as "Sewer Sediment" and "Inaccessible Soil Adjacent to Sewer Lines". The potential environmental release and transport mechanisms associated with these sources are discussed in Section 5.2.

## 5.2 INACCESSIBLE SOIL OPERABLE UNIT CONTAMINANT RELEASE AND TRANSPORT MECHANISMS

Under current conditions of the ISOU, direct contact exposures (i.e., via incidental ingestion, dermal contact, inhalation of dusts, and external radiation) can potentially occur at exposed inaccessible soil source areas and from radiologically contaminated soil on building and structural surfaces. Direct contact exposures with inaccessible soil beneath buildings, as well as with soil adjacent to sewer lines, would not occur under existing conditions and therefore this scenario is not considered in the ISOU CSM.

Indirect contact exposures to contaminants comprising all ISOU source areas could be possible if the contaminants can migrate from the source areas to some downgradient/downwind receptor location or medium. This in turn, would be possible if the migration pathways are supported by environmental release and transport mechanisms. Release mechanisms (e.g., leaching, fugitive dust emissions, etc.) are those environmental processes that cause some or all of the contaminant concentrations to become unbound or mobilized from a source. Once released from a source, transport mechanisms provide a pathway (e.g., air transport, ground-water transport, etc.) by which contaminants can migrate in or through an environmental medium (i.e., "transport medium"). Generally, the transport pathways expected to be significant in the migration of contaminants within or away from ISOU sources include air transport, ground-water transport, and surface-water runoff. Generally, these pathways and associated release mechanisms are summarized below:

- Air Transport Pathways
  - Particulate emissions (by wind dispersion) from inaccessible soil areas with little or no vegetative or unconsolidated covers.
  - Particulate emissions from structural surfaces in the forms of dust potentially generated by construction/renovation activities and oxidation (from metal surfaces).

- Ground-Water Transport Pathways
  - Infiltration/percolation of contaminants to ground water.
  - Horizontal migration to downgradient locations/media (Mississippi River surface water and sediment).
- Surface Runoff Transport Pathways
  - Surface runoff to downgradient locations/media (Mississippi River surface water and sediment).

ISOU-specific mechanisms of release and transport from sources, exposure media and exposure routes to receptors, are described below, and presented in the schematic CSM in Figure 5-1.

In the CSM, those pathways that are identified as being potentially complete and "significant" are those that are comprised of all four of the elements presented in Section 5.0, plus all of the following:

- MED/AEC contaminant concentrations at the source that exceed screening levels;
- contaminant-specific chemical/physical characteristics that strongly facilitate release and transport; and
- medium-specific chemical/physical characteristics that strongly facilitate release and transport.

ISOU pathways determined to be complete (i.e., per the four main elements presented in Section 5.0), can be characterized as "insignificant" by any of the following:

- low MED/AEC contaminant concentrations (i.e., below screening levels) at the source;
- contaminant-specific chemical/physical characteristics that weakly facilitate release and transport; and/or
- medium-specific chemical/physical characteristics that weakly facilitate release and transport.

An environmental migration pathway from a source is "incomplete" if it lacks any of the four necessary elements presented in Section 5.0.

The three transport pathways (air transport, ground-water transport, and surface water runoff) and associated release mechanisms, along with the manner in which support contaminant migration away from the sources identified in Section 5.1 are discussed in detail in the following sections.

### 5.2.1 Air Transport Pathways

#### *5.2.1.1 Air Transport Pathways for Inaccessible Soil Beneath Unconsolidated Cover or No Cover*

Under current conditions, the particulate emission of contaminants from inaccessible soil to the air is not a significant pathway due to the mitigating presence of structural barriers (e.g., buildings, walkways, roads, etc.) over most of the ISOU. Contaminants adsorbed to inaccessible soil may be released to the air as a result of wind agitation, and then be transported by the wind as fugitive airborne dust. Soil erosion by wind is more likely to occur in areas with sparse vegetative cover. Because each of the exposed inaccessible soil areas are covered by gravel and are small relative to total combined area of the SLDS and VPs, wind erosion of contaminated dusts from these small areas is likely to be insignificant. This pathway is rendered even more insignificant by the presence of tall buildings in close proximity to each other in the SLDS plant properties and VPs that can interfere with the air transport of wind-blown dusts. Although considered to be insignificant, this transport pathway could result in contaminant exposures via the inhalation of fugitive dusts at downwind locations.

Aside from particulate emissions, gaseous emissions of Rn-222, a decay product of Ra-226, could occur from all inaccessible soil areas. However, given the relatively low levels of site-related Ra-226 concentrations measured in the soil, site-related Rn-222 is not considered to be significant, and therefore, was not investigated during the RI.

##### *5.2.1.2 Atmospheric Transport of Dust Emissions from Construction/Renovation Activities on Buildings and Structures*

The RI characterization shows that exterior building contamination at the SLDS is primarily fixed with minimal amounts of removable contamination. However, building renovations may release breathable particulate emissions into the air which could result in inhalation and ingestion exposures to renovation workers. Under this scenario, emissions of contaminated particulates into the air could become a significant pathway via the inhalation route.

##### *5.2.1.3 Air Transport of Oxidized Particles from Building and Structures*

Elevated activities measured on exterior building/structure surfaces are essentially fixed and are not expected to be removable. However, prolonged oxidation of the metallic surfaces may result in loose contaminated particulates that could become airborne by high wind agitation. This would result in the atmospheric transport to other on-site or off-site areas and subsequent deposition of the contaminated oxidized material in those areas. However, because the areas of elevated activity are relatively small and the potential for releases is minimal, this pathway is considered to be potentially complete but insignificant.

#### 5.2.2 Water Transport Pathways

##### *5.2.2.1 Ground-Water Transport Pathways for Inaccessible Soil Beneath Unconsolidated Cover or No Cover*

Under current conditions, contaminants in inaccessible soil areas that are exposed to the environment can potentially migrate vertically through the soil to underlying ground water. At the SLDS plant properties and VPs, the primary mechanisms for release of contaminants into ground water are the: (1) leaching of contaminants via infiltration of rainwater through contaminated surface or subsurface soil, and (2) leaching of contaminants from contaminated soil due to fluctuations in the water table. Once in ground water, contaminants could then be transported to downgradient wells that draw from those aquifers, or to the nearest surface water body, the Mississippi River.

Once in the ground water, contaminants may migrate horizontally to drinking water wells that draw from those aquifers, or to the Mississippi River. However, the cumulative impact of inaccessible soil contamination to ground water is reduced by the presence of overlying structural barriers that mitigate or minimize infiltration/percolation to ground water. As described in Section 3.3, the use of ground water at the SLDS as a drinking water source is highly unlikely. Therefore, no human exposures to ground water are expected.

The concentrations of ISOU contaminants that may reach the underlying ground water could be transported to the Mississippi River via HU-B, which is hydraulically connected. However, during ground-water transport, attenuation and dispersion processes would reduce concentrations prior to reaching the river. Upon reaching the ground-water/surface water interface, it is expected that the already dilute ISOU contaminant concentrations entering the river would immediately undergo nearly infinite dilution due to the large volumetric water flow of the river. Therefore, ISOU contaminant concentrations in the river would not likely cause any impacts to human health or to ecological receptors.

In summary, the soil to ground-water transport pathway is considered potentially complete but insignificant for areas where inaccessible soil is exposed to the environment. This is because the minimal concentrations reaching into ground water are expected to undergo immediate mixing in the aquifer, followed by dilution and attenuation during transport. Once in ground water, no human exposures are expected because ground water is not being used as a potable source. Likewise, the subsequent release of contaminants from ground water to surface water is even less significant because of the infinite dilution expected from the large volumetric water flow of the Mississippi River. Ingestion and dermal exposures to contaminants by aquatic life, though insignificant, could occur in the surface water and sediments.

#### *5.2.2.2 Water Transport Pathways Sediment in Sewers and for Soil Adjacent to Sewers*

Metal contaminants present in water and sediment contained within sewers could leak to underlying and/or adjacent inaccessible soil via structural defects such as cracks and breaks. Once sewer sediment contamination has reached adjacent soil, the more likely environmental fate would involve downward migration to ground water, followed by possible transport to downgradient wells, or to the nearest downgradient surface water body, the Mississippi River. The primary mechanisms of release of contaminants from source sewer soils into ground water would be: (1) the leaching of contaminants via infiltration of rainwater or sewer line water through contaminated subsurface soil, and (2) leaching of contaminants from contaminated soil adjacent to sewer lines due to fluctuations in the water table. Water from precipitation events can infiltrate to the subsurface environment in areas where there is no impermeable ground cover (pavement, buildings, etc.). Of the three areas of contaminant sources identified at Plant 1, Plant 6, and DT-2, rainwater infiltration would likely only occur at DT-2 due to the presence of unconsolidated cover at the levee. Water reaching the subsurface contaminant sources could cause the contaminants to leach from the soils to which they are bound and to migrate deeper into the subsurface environment.

Similar to rainwater, water from adjacent sewer lines could infiltrate into the previously described subsurface soil contaminant sources and trigger releases to the deeper subsurface environment. Water from sewer lines can originate from inside or outside of the lines. Active sewer lines are likely to have periods of significant interior water flow during which water can leak through cracks or breaches into the adjacent soils. Inactive sewers may also leak water during periods of interior flow, which are likely to be less significant than active sewer line flows. Both active and inactive lines can also act as water conduits, or preferred water migration pathways, whereby subsurface water would flow along the exteriors of the lines, while allowing for some vertical migration to the deeper subsurface environment.

The soil to ground-water transport pathway is considered potentially complete but insignificant for soil adjacent to sewer lines. This is because the minimal concentrations reaching into ground water are expected to undergo immediate mixing in the aquifer, followed by dilution and attenuation during transport. Once in ground water, no human exposures are expected because ground water is not being used as a potable source. Likewise, the subsequent release of contaminants from ground water to the Mississippi River is even less significant because of the infinite dilution expected from the large volumetric water flow. Ingestion and dermal exposures to contaminants by aquatic life, though insignificant, could occur in the surface water and sediments.

### 5.2.3 Surface-Water Runoff Transport Pathways

#### *5.2.3.1 Surface Runoff Transport Pathways for Inaccessible Soil Beneath Unconsolidated Cover or No Cover*

Surface runoff from inaccessible soil areas under unconsolidated cover could occur following a rain event or snowmelt. This action may erode soil bearing contaminants and carry those contaminants to downgradient locations or media via overland runoff water. However the presence of the gravel cover would reduce erosion of the underlying soil. Additionally, an extensive storm-water sewer drainage system is present at the SLDS where the ground surface is primarily covered by concrete, asphalt, or is under roof. In these areas, surface water is quickly captured by the drainage system and collected and treated by the MSD. Therefore, the vast majority of surface-water runoff resulting from storm events is captured by the storm sewer system.

There are no surface ditches or streams leaving the SLDS plant properties or VPs, except for a surface ditch in the far northern portion (DT-9) of the ISOU study area, which channels water flows to the north. Rainfall that does not result in runoff initially percolates through the upper few feet of fill material. The water accumulates at the upper surface of the natural soil, which is relatively impermeable due to its high clay content. The only property with conditions that vary from the industrial nature of the remaining properties is the eastern portion of the SLDS, which lies along the Mississippi River levee and is covered primarily by grass and has a less extensive storm sewer system. Surface water is this area would run directly into the Mississippi River.

Any contaminant runoff that may occur from environmentally exposed inaccessible soil is expected to be minimal, and could be transported to the nearest downgradient surface-water body, the Mississippi River. However, due to the large volumetric water flow of the river, it is expected that the minimal contaminant concentrations in the runoff entering the river would immediately undergo infinite dilution to undetectable concentrations at the surface-water interface, thus resulting in surface-water concentrations that would be insignificant relative to exposures that could impact human health.

For these reasons, the soil to surface water transport pathway is considered to be potentially complete but insignificant for areas of inaccessible soil exposed to the environment. Likewise, potential exposures to humans and/or aquatic life to surface water and sediment, via the ingestion and dermal routes, are also insignificant.

#### *5.2.3.2 Surface Runoff Transport of Soil and Oxidized Particles from Buildings and Structural Surfaces*

Prolonged oxidation of the metallic surfaces identified in Section 5.1.5 may result in loose contaminated particulates that could be washed away, along with soil particulates also adhered to a building/structure during a rain event. The release of contaminated soil and oxidized particles in this manner could occur as a result of the physical flushing action of the rain water, in conjunction with the slightly acidic pH that is characteristic of rain water. These release mechanisms would result in radiological contaminants in runoff from the building to the ground surface, and then to the combined sewer system, which flows to wastewater treatment facilities. However, during periods of heavy rain, the storm sewers can become overloaded resulting in some storm water not being treated. Contaminant concentrations in the runoff are expected to be minimal due to the minimal releases expected from the small, localized building source areas, in conjunction with the large subsequent dilution that would occur over the course of transport the storm sewers, then to the wastewater treatment facility. However, some residual levels of contamination may remain on the ground and not flow to the storm sewers during light or short rain events. Similarly, these residual levels of activity left on the ground surface would not be significant because only minimal releases would be expected from the small building source areas and because most of the existing contamination on the buildings is not easily removed by water action alone. Exposures to residual contamination on the ground would be insignificant. Therefore, this pathway is considered to be potentially complete but insignificant.

## 5.3 CONTAMINANT PERSISTENCE AND MOBILITY

Persistence and mobility are two key terms used to describe the movement and partitioning of chemicals in environmental media (i.e., air, surface water, ground water, soil, and sediment) and their likelihood of reaching an exposure point. Persistence is a measure of how long a compound will exist in air, water, or soil before it degrades or transforms, either chemically or biologically, into some other chemical. Mobility is defined as the potential for a chemical to migrate through a medium.

### 5.3.1 Chemical and Physical Properties

Chemical and physical properties that affect the fate and transport of metal and radiological COPCs include water solubility, speciation, partitioning and sorption, and degradation (or decay) rate. These properties are generally interrelated and are a function of a number of other variables, including ORP, pH, temperature, and the type and concentration of other chemicals capable of bonding with metal ions (e.g., sulfate, iron oxides, and natural organic matter).

### 5.3.2 Water Solubility

The water solubility of a chemical is one of the primary properties affecting the environmental transport of a chemical. Water solubility is the maximum concentration of a chemical that can dissolve in pure water at a given temperature and pH. Highly soluble chemicals [i.e., chemicals with solubility greater than 1,000 milligrams per liter (mg/L)] can be rapidly leached from contaminated soil and have a tendency to remain dissolved in water. They are less likely to partition to soil/sediment particles or volatilize. They are likely to be mobile and, therefore, are less likely to persist in the environment. Chemicals with lower water solubility (i.e., less than 1,000 mg/L) have a tendency to adsorb to soil and are generally less mobile. The solubility of chemicals that are not readily soluble in water can be enhanced in the presence of organic solvents or under acidic conditions.

### 5.3.3 Speciation

The fate and transport of metals is primarily driven by chemical speciation. Speciation can be described in terms of the chemical form (i.e., the oxidation state, charge, proportion, and nature of the complexed forms) and sometimes the physical form (distribution among soluble, colloidal or particulate forms, and solid phases) in which it occurs (Moulin et al. 2005).

A variety of factors influence metal speciation, including pH, ORP, ionic strength, and the types and concentrations of ligands and complexing agents. In the pH range of natural water (between 5 and 9.5) and under aerobic conditions, free metal ions occur mainly at the low end of the pH range. With increasing pH, the carbonate and then oxide, hydroxide, or silicate solids precipitate (Connell and Miller 1984). In general, reduction of pH leads to increased desorption and remobilization of metal cations.

In the soil environment, metals can exist as cations (having a positive charge), anions (having a negative charge), or neutral species (having a zero charge). Their ionic form significantly affects their sorption, solubility, and mobility. For example, most soil particles are negatively charged; as a consequence, metal cations have a greater tendency to be sorbed by soil particles than do metal anions and, therefore, would have lower mobility (USEPA 2007a).

Speciation is affected in two ways by oxidation-reduction (redox) conditions: (1) a direct change in the oxidation state of the metal ions, and (2) redox changes in available and competing ligands or chelates. Redox is typically expressed in terms of ORP where a positive value typically indicates oxidizing conditions and a negative one indicates reducing conditions. Reduced iron and manganese species are soluble and tend to be more mobile; whereas, oxidized forms of these metals (hydrous iron and manganese oxides) are in the particulate form and tend to cause other metals to sorb to their surfaces and tend to be less mobile.

### 5.3.4 Partitioning and Sorption

Partitioning and sorption are important mechanisms that affect the fate and transport of contaminants. The distribution of chemicals between a solid (soil or sediment), liquid, and gas is described as partitioning. The term sorption refers to removal of a solute from solution to a solid phase. The related term, adsorption, refers to two-dimensional accumulation of a solute on a solid surface (Smith 1999). Adsorption is generally pH-dependant, and pH changes exert strong controls on partitioning of contaminants between the aqueous and solid forms.

Four types of partitioning coefficients are important in predicting the behavior and mobility of chemicals within the environment: the soil-water partitioning coefficient ($K_d$), the organic carbon partitioning coefficient ($K_{oc}$), the octanol-water partitioning coefficient ($K_{ow}$), and an air-water partitioning coefficient based on the Henry's Law constant (K). The $K_{oc}$, $K_{ow,}$ and K values are primarily used when evaluating organic chemicals. They generally are not important factors for evaluating the fate and transport of the metals and radionuclide COPCs for the ISOU and, therefore, are not discussed further.

Sorption and partitioning of inorganics can be expressed in terms of a $K_d$, also known as a distribution coefficient. It is simply the ratio of the concentration of a chemical in a solid phase to the corresponding aqueous-phase concentration. The $K_d$ measures the relative mobility of a chemical in the environment and is typically expressed in units of liters per kilogram. In general, a high $K_d$ value implies that the contaminant is tightly bound to the soil and will migrate slowly, while a small value implies the opposite. Values for $K_d$ have been compiled for many of the common contaminants under a variety of hydrogeologic settings. The literature $K_d$ values have wide ranges due to the large number of variables that can affect the measurements. The most important variables include pH and salinity of the water, grain size and mineralogy of the soil, concentrations of competing ions present, and the organic carbon content of the soil. Important adsorbent materials include iron oxides and hydroxides, manganese oxide, clay minerals, and particulate organic matter. Organic matter may form chelates or ligands with some metals, resulting in greater partitioning to soil with high organic content. The organic material in the soil also may sorb certain metals by other solutes through cation exchange.

### 5.3.5 Radioactive Decay Rate

The decay rate of a radionuclide is expressed in terms of a radionuclide-specific half-life and can be on the order of days, weeks, or years. The half-life of a radioactive substance is the time in which half of the atoms are transformed to another substance or daughter product.

Non-radioactive metals generally exhibit no potential to decay or degrade in environmental media. However, they may undergo chemical species transformations that affect their mobility in the environment. Radionuclides are subject to radioactive decay, which affects their environmental persistence. In general, decay of radionuclides occurs by the emission of alpha particles (a combination of two protons and two neutrons) and beta particles (negatively charged high-speed electrons). Decay of many radionuclides is accompanied by emission of gamma rays. The first radionuclide on the decay chain is called the parent compound, and specific products result from the decay of each parent. The parent radionuclides of importance at the SLDS are U-238, U-235, and Th-232. These parent radionuclides each yield radioactive decay products.

The U-238 decay series includes a number of decay products that would rapidly diminish in the environment because of their short half-lives if their long-lived parent isotopes were not present. However, continued presence of the long-lived isotopes U-238, uranium-234 (U-234), Ra-226, and Pb-210 at relatively constant activity concentrations will cause their short-lived decay products to persist in solid media. For instance, Pb-210, which was not identified as a PCOC, has the shortest half-life of any of these COPCs (21 years). The half-life of Ra-226 is about 1,600 years, and the uranium isotopes have half-lives ranging from about 250,000 years to 4.5 billion years. Thus, radioactive decay is not of practical significance as a mechanism for reducing the COPC concentrations, particularly in sediment and surface materials.

## 5.4 CHARACTERISTICS OF INACCESSIBLE SOIL OPERABLE UNIT CONTAMINANTS OF POTENTIAL CONCERN

Radiological forms of uranium, thorium, and radium, as well as non-radiological metals (i.e., arsenic, cadmium, and lead) were retained as COPCs based on the RI evaluation presented in Section 4.0. Table 4-9 shows that radiological COPCs were identified in inaccessible soil beneath and near buildings at various plants and VPs, in soil adjacent to sewer lines, and beneath the levee, roadways, and RRs. Arsenic, cadmium, and lead are identified as COPCs in one Plant 1 sewer soil location. This section describes the significant characteristics of each of the COPCs as they pertain to fate and transport.

### 5.4.1 Radionuclides

Residuals from the processing of uranium ore (i.e., radium, thorium, uranium, and their decay products) were inadvertently released into the environment. Radionuclides may exist either in solution or associated with solid particulates. In water, the partitioning of an element between dissolved and adsorbed forms is influenced greatly by the geochemical characteristics of the site. It is necessary, therefore, to rely on estimates of the $K_d$. The higher the $K_d$, the more adsorbed the radionuclide will be on the solid particulates and less in solution (USEPA 1993).

Chemical factors that influence the mobility of radionuclides in water include valence state, solubility, and redox conditions. Low-pH waters tend to carry more dissolved heavy radionuclides than high-pH waters. Thorium in the +4 valence state [Th(IV)] is highly immobile in all aqueous environments; whereas, radium in the +2 valence state [Ra(II)] is often mobile.

#### *5.4.1.1 Uranium*

Uranium is a common, naturally occurring, radioactive substance. Uranium is an actinide element and has the highest atomic mass of any naturally occurring element. In its refined state, it is a heavy, silvery-white metal that is malleable, ductile, slightly paramagnetic, and very dense, second only to tungsten. In nature, it is found in rocks and ores throughout the earth, with the greatest concentrations in the United States in the western states of Arizona, Colorado, New Mexico, Texas, Utah, and Wyoming (USEPA 1991b; Lide 1994). In its natural state, uranium occurs as a component of several minerals such as carnotite and uraninite (including the variety commonly known as pitchblende) but is not found in the metallic state.

Uranium also may be introduced into the environment primarily by release as a result of mining and milling activities, by uranium processing facilities, or by burning coal.

Natural uranium is a mixture of the three isotopes U-234, U-235, and U-238. All three are the same chemical, but they have different radioactive properties. The only mechanism for decreasing the radioactivity of uranium is radioactive decay. Because all three of the naturally occurring uranium isotopes have very long half-lives (U-234 = $2.5 \times 10^5$ years; U-235 = $7.0 \times 10^8$ years; and U-238 = $4.5 \times 10^9$ years), the rate at which the radioactivity diminishes is very slow (NCRP 1984). Therefore, the activity of uranium remains essentially unchanged over periods of thousands of years.

By weight, natural uranium is about 0.01% U-234, 0.72% U-235, and 99.27% U-238. About 48.9% of the radioactivity is associated with U-234, 2.2% is associated with U-235, and 48.9% is associated with U-238. The shorter half-life makes U-234 the most radioactive, while the longer half-life makes U-238 the least radioactive. Essentially, U-234 will be about 20 thousand times more radioactive and U-235 will be 6 times more radioactive than U-238 (ATSDR 1999).

When U-238 gives off its radiation, it decays through a series of different radioactive materials, including U-234. This series, or decay chain, ends when it reaches the stable, non-radioactive element lead.

The mobility of uranium in soil and its vertical transport (leaching) to ground water depend on properties of the soil such as pH, ORP, concentration of complexing anions, porosity of the soil, soil particle size, and sorption properties, as well as the amount of water available (Allard et al. 1982; Bibler and Marson 1992). The sorption of uranium in most soil is such that it may not leach readily from surface soil to ground water, particularly in soil containing clay and iron oxide (Sheppard et al. 1987); although, other geological materials such as silica, shale, and granite have poor sorption characteristics (Bibler and Marson 1992; Erdal et al. 1979; Silva et al. 1979; Ticknor 1994). Redox conditions are important in the geologic transport and deposition of uranium. Oxidized forms of uranium [U(VI)] are relatively soluble and can be leached from the rocks and migrate in the environment. When strong reducing conditions are encountered (e.g., presence of carbonaceous materials or hydrogen sulfide), precipitation of the soluble uranium will occur (ATSDR 1999).

As with soil, factors that control the mobility of uranium in water include ORP, pH, and sorbing characteristics of sediment and the suspended solids in the water (Brunskill and Wilkinson 1987; Swanson 1985). The chemical form of uranium determines its solubility. Uranium behaves differently in oxidizing and reducing waters because of its two valence states [U(IV) and U(VI)]. In the reduced state, uranium is relatively immobile. In the oxidized state, uranium readily forms highly soluble complexes such as $UO_2\,(CO_3)_2^{2-}$ (McKelvey et al. 1955), which is very mobile in most natural surface-water and shallow ground-water environments (URS 2005).

### *5.4.1.2 Thorium*

Thorium is a naturally occurring radioactive substance. In the environment thorium exists in combination with other minerals, such as silica. Small amounts of thorium are present in all rocks, soil, water, plants, and animals. Soil contains an average of about 6 parts of thorium per million parts of soil (6 parts per million). Some rocks in underground mines contain thorium in a more concentrated form. After these rocks are mined, thorium is usually concentrated and changed into thorium dioxide or other chemical forms.

Thorium is a metallic element of the actinide series. Thorium occurs in nature in four isotopic forms: Th-228, Th-230, Th-232, and Th-234. Thorium, like all radioactive materials, is not stable and breaks down through a decay chain/series of decay products until a stable product is formed. During these decay processes, radioactive substances are produced. These include radium and radon. These substances give off radiation, including alpha and beta particles and gamma radiation. Th-228 is the decay product of naturally occurring Th-232 and both Th-234 and Th-230 are decay products of natural U-238. Of these naturally produced isotopes of thorium, only Th-232, Th-230, and Th-228 have long enough half-lives to be environmentally significant. More than 99.99% of natural thorium is Th-232; the rest is Th-230 and Th-228.

The mobility of thorium in water is low because its solubility is low; therefore, thorium will most likely be present in suspended matter and sediment (Platford and Joshi 1986). Sediment resuspension and mixing also may control the transport of particle-sorbed thorium in water. The concentration of dissolved thorium in water may increase duc to the formation of soluble complexes with carbonate, humic materials, or other ligands in the water (LaFlamme and Murray 1987).

The fate and mobility of thorium in soil are governed by the same principles that apply to water. In most cases, thorium will remain strongly sorbed to soil and its mobility will be very slow (Torstenfelt 1986). The thorium content of soil normally increases with an increase in the clay content of soil (Harmsen and De Haan 1980). Normally, thorium compounds will not migrate long distances in soil. They will persist in sediment and soil (ATSDR 1990a). The contamination of ground water through the transport of thorium from soil to ground water will not occur in most soil, except soil that has low sorption characteristics and has the capability to form soluble complexes. The presence of ions or ligands ($C0_3^{2-}$, humic matter) in soil that can form soluble complexes with thorium should increase its mobility in soil. Chelating agents produced by certain microorganisms (*Pseudomonas aeruginosa*) present in soil may enhance the dissolution of thorium in soil (Premuzic et al. 1985). The plant-soil transfer ratio for thorium is less than 0.01 (Garten 1978), thus indicating that it will not bioconcentrate in plants from soil.

### *5.4.1.3 Radium*

Radium is a naturally occurring, silvery white radioactive metal that can exist as several isotopes. Usually, natural concentrations are very low. However, weathering and other geologic processes can form concentrated deposits of naturally radioactive elements, especially uranium and radium. Radium in soil and sediment does not biodegrade nor participate in any chemical reactions that transform it into other forms (ATSDR 1990b). The only degradation mechanism in air, water, and soil is radioactive decay.

Radium forms when isotopes of uranium or thorium decay in the environment. As a decay product of uranium and thorium, it is common in virtually all rock, soil, and water. Radium's most common isotopes are Ra-226, Ra-224, and Ra-228. Ra-226 is found in the U-238 decay series, and Ra-228 and Ra-224 are found in the Th-232 decay series. Ra-226, the most common isotope, is an alpha emitter, with accompanying gamma radiation, and has a half-life of about 1,600 years. Ra-228 is principally a beta emitter and has a half-life of 5.76 years. Ra-224, an alpha emitter, has a half-life of 3.66 days (USEPA 2009a). Radium decays to form isotopes of the radioactive gas radon, which is not chemically reactive. Ra-226 decays by alpha particle radiation to an inert gas, Rn-222, which also decays by alpha particle radiation and has a short half-life of 3.8 days. Stable lead is the final product of this lengthy radioactive decay series.

Radium is known to be "readily adsorbed to clays and mineral oxides present in soil, especially near neutral and alkaline pH conditions" (Smith and Amonette 2006). Consequently, it is usually not a mobile constituent in the environment. Radium $K_d$ values for clay minerals and other common rock-forming minerals have ranged from 2,937 to 90,378 milliliters per gram in alkaline solutions (Benes et al. 1985; Benes et al. 1986). The magnitude of these adsorption constants indicates that partitioning to solid surfaces is a major removal mechanism of radium from water. The tendency for radium to coprecipitate with barite, and sparingly with soluble barium sulfate, is well known. Therefore, it is likely that radium in water does not migrate significantly from the area where it is released or generated (USEPA 1985). Radium may be transported in the environment in association with particulate matter. Its concentration is usually controlled by adsorption-desorption mechanisms at solid-liquid interfaces and by the solubility of radium-containing minerals.

Radium and its salts are soluble in water. Radium in water exists primarily as a divalent ion ($Ra^{2+}$) and has chemical properties that are similar to barium, calcium, and strontium. The solubility of radium salts in water generally increases with increased pH levels. The removal of $Ra^{2+}$ by adsorption has been attributed to ion exchange reactions, electrostatic interactions with potential determining ions at mineral surfaces, and surface-precipitation with $BaSO_4$. The adsorptive behavior of $Ra^{2+}$ is similar to that of other divalent cationic metals in that it decreases with an increase in pH and is subject to competitive interactions with other ions in solution for adsorption sites. In the latter case, $Ra^{2+}$ is more mobile in ground water that has a high total dissolved solids content. Limited field data also support the generalization that radium is not very mobile in ground water. It also appears that the adsorption of $Ra^{2+}$ by soil and rocks may not be a completely reversible reaction (Benes et al. 1984, 1985; Landa and Reid 1982). Hence, once adsorbed, radium may be partially resistant to removal, which would further reduce the potential for environmental release and human exposure.

### 5.4.2 Metals

All soil naturally contains a variety of metals. The presence of metals in soil is, therefore, not indicative of contamination. The background concentration of metals in uncontaminated soil is primarily related to the geology of the parent material from which the soil was formed. Depending on the local use of an area and the local geology, the concentration of metals in soil may exceed average concentrations for the United States.

The anthropogenic sources of metal to soil include diverse manufacturing, mining, combustion, and pesticide activities and deposition from atmospheric sources resulting from oil and coal combustion, mining and smelting, steel and iron manufacturing, waste incineration, phosphate fertilizers, cement production, and wood combustion (USEPA 1992a). Uranium-bearing ores that were processed by MED/AEC may have contained elevated levels of some metals (e.g., arsenic, cadmium, and lead) and may have also contained cadmium, a constituent of pyrite, which was a mineral constituent of the uranium ore. Although uranium (elemental) concentrations do not exceed the screening level, arsenic, cadmium, and lead concentrations do exceed the respective screening levels.

Although each metal has unique characteristics, as a group, metals are persistent in the environment and do not biodegrade but may alter in form. The primary factor influencing the mobility and persistence of metals is their speciation, which is affected by the geochemistry of the environment. Speciation refers to the occurrence of a metal in a variety of chemical forms. These forms may include free metal ions, metal complexes dissolved in solution and sorbed on solid surfaces, and metal species that have been coprecipitated in major metal solids or that occur in their own solids (USEPA 2007a). Some metals can be transformed to other oxidation states in soil, making them less soluble and, thereby, reducing their mobility and toxicity (USEPA 1992a).

Metals are typically attenuated by clay soil, such as that found in the subsurface environment at the SLDS, primarily by precipitation and exchange processes, and not likely to leach significantly under natural conditions (i.e., undisturbed conditions and relatively neutral soil pH).

Three metal PCOCs have been retained as COPCs based on the RI evaluation presented in Section 4.0: arsenic, cadmium, and lead. Concentrations of all three metals have been detected above screening levels. Therefore, the physical/chemical characteristics of arsenic, cadmium, and lead are discussed in Sections 5.4.2.1 through 5.4.2.3.

#### *5.4.2.1 Arsenic*

Arsenic is a natural element found in the atmosphere, soil, rocks, natural waters, and organisms. There are numerous anthropogenic sources of arsenic. It is a byproduct of metal smelting and the burning of fossil fuels and also has been used as a component of pesticides, wood preservatives, glass, and pharmaceuticals. The largest natural source is volcanic activity (WHO 2001). Arsenic is mobilized in the environment through a combination of natural processes such as wind or water erosion of small particles, leaching from soil or rock, volcanic activity, and biological activity, as well as through a range of anthropogenic activities.

Transport of arsenic in water depends upon its chemical species, oxidation state, and on interactions with other materials present. In an oxidized environment, arsenic is generally present as arsenate ($As^{5+}$), an immobilized form that tends to be ionically bound to soil. However, arsenate adsorption by soil is significantly reduced in environments where phosphate concentrations are high (WHO 2001). Sorption of arsenate is greatest at low pH but also depends on the availability of sorbing minerals. Under reduced conditions, arsenate is transformed to arsenite ($As^{3+}$), which is water soluble and, therefore, more mobile than arsenate. In a reducing environment and in the presence of sulfur, the relatively insoluble sulfides ($As_2S_3$ and AsS) form.

Arsenic minerals and compounds are readily soluble but migration is generally limited due to strong adsorption by clays, organic matter, iron oxides, magnesium oxides, and aluminum hydroxides. Arsenic adsorption does not appear to be significantly related to soil organic carbon or cation exchange capacity (Hayakawa and Watanabe 1982).

Arsenic is not subject to degradation. However, geochemical conditions created by microbial activity may create conditions that mobilize arsenic. Arsenic in water and soil may be reduced by fungi, yeasts, algae, and bacteria. Varying ORP conditions also may affect the speciation (valence state) of arsenic, which may affect both the toxicity and mobility.

Arsenate is likely the predominant water-soluble arsenic species under the oxidizing conditions found in the shallow soil and ground water at the SLDS. Arsenate is expected to have limited mobility at the SLDS because it is generally sorbed by iron, manganese, aluminum hydroxides, and clay minerals under near-neutral pH conditions.

#### *5.4.2.2 Cadmium*

Cadmium occurs naturally in the environment in deposits of zinc, lead, and copper-bearing ores; black shales; coal; and other fossil fuels. It is also released during volcanic eruptions. Typical concentrations in uncontaminated soil are less than 1 mg/kg (USEPA 1999a). Anthropogenic sources of cadmium include electroplating, paint pigments, plastic stabilizers, nickel-cadmium batteries, alloys, iron and steel production, mining of non-ferrous metals (e.g., lead and zinc), tire wear, coal combustion, oil burning, and limited use in some fertilizers (Korte 1999).

Cadmium is relatively mobile in soil and water systems. As with other cationic metals, cadmium sorption to mineral surfaces (especially oxide minerals) exhibits pH dependency, increasing as conditions become more alkaline (pH >6). Under acidic conditions (pH <6), cadmium is desorbed from soil (USEPA 1995a). In ground water with low to near-neutral pH, essentially all of the dissolved cadmium is expected to exist as the uncomplexed $Cd^{2+}$ ion. Under these conditions, cadmium also may form complexes with chloride and sulfate. Sorption also is influenced by the cation exchange capacity of clays, carbonate minerals, and organic matter present in soil. Under reducing conditions, cadmium is expected to form insoluble CdS precipitates or coprecipitates with FeS.

The most common cadmium species is likely $Cd^{2+}$ under the oxidizing conditions typical of the shallow soil and ground water at the SLDS. The solubility and mobility of cadmium are greatly influenced by pH. Under the near-neutral pH conditions observed in shallow ground water at the SLDS, cadmium is expected to be adsorbed by the soil solid phase or to be precipitated and mobility is expected to be reduced.

#### *5.4.2.3 Lead*

Lead is a heavy metal that occurs naturally in the earth's crust. It is rarely found naturally as a metal and, instead, is usually found combined with other elements to form lead compounds. It occurs as the mineral galena and also occurs in silicate minerals, such as feldspars, micas, amphiboles, and pyroxenes. It is usually found in ores with zinc, silver, and copper. Because it strongly sorbs onto clay minerals, it is also naturally found in some shales and clays. Lead is widespread in the environment as a result of human activities, primarily due to lead battery manufacturing, coal and oil burning, ammunition manufacture, metal smelting and processing, and to its former use in paints and gasoline (ATSDR 2007).

Lead is not very mobile in soil and, as a result, is typically present only in very low concentrations (on the order of $10^{-2}$ to $10^{-3}$ mg/L) in most river water and ground water (Hitchon et al. 2002). Under most conditions, $Pb^{2+}$ and lead-hydroxy complexes are the most stable forms of lead (Smith et al. 1995). The primary processes influencing the fate of lead in soil include adsorption, ion exchange, precipitation, and complexation with sorbed organic matter. The amount of lead that leaches to ground water is dependent on pH; lead sorbs extensively at much lower pH values than cadmium.

Based on its chemical characteristics, the most common lead species in the shallow soil and ground water at the SLDS are likely $Pb^{2+}$ and lead-hydroxy complexes. Most lead would be retained in the soil due to adsorption, ion exchange, precipitation, and complexation with sorbed organic matter. This greatly limits the mobility of lead at the SLDS.

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# 6.0 BASELINE RISK ASSESSMENT

The ISOU BRA was conducted to determine baseline dose and risks to the most likely human receptors identified at the SLDS properties based on assumed potential current and future exposures to radiological and metal COPCs identified in ISOU media (Section 4.0). Analytical data acquired primarily during the RI, as well as appropriate data from previous USACE investigations at the SLDS, were used in the preparation of this BRA. The BRA consists of two components: the HHRA (Section 6.1) and the Ecological Assessment (Section 6.2).

## 6.1 HUMAN HEALTH RISK ASSESSMENT

The scope of the HHRA includes all media not addressed under the 1998 ROD (USACE 1998a), as previously described in detail in Section 1.1.2, that exceed the health-based screening levels presented in Section 4.0. The purpose of the HHRA is to identify those ISOU media and properties that exhibit dose or risk that exceed the target dose value of 25 mrem/yr or USEPA's target CR of 1.0E-05 (1 in 100,000). Although USEPA's *National Oil and Hazardous Substances Contingency Plan* (NCP) (USEPA 1990) identifies 1.0E-06 as the point of departure for all risk evaluations, the CR of 1.0E-05 represents the mid-point of USEPA's acceptable target CR range of 1.0E-06 to 1.0E-04. Application of the target CR of 1.0E-05 is consistent with the current and expected future land use of the SLDS as a heavily industrial area in an urban setting, and facilitates the identification of those SLDS properties that should be retained for further evaluation in the FS.

Figure 6-1 presents an overview of the ISOU HHRA process applied to each of the specific properties at the SLDS. For all media, the HHRA itself is generally comprised of several significant steps (identification of COPCs, exposure assessment toxicity assessment, and dose and risk characterization), the methods and results of which are summarized in Sections 6.1.1 and 6.1.2. The detailed HHRA is presented in Appendix K, along with all supporting data, information, and calculations provided in Appendices L through R. The results of the HHRA have determined that of the 16 total SLDS properties evaluated for any of the ISOU media (i.e., those properties retained for the HHRA based on the screening level exceedances presented in Section 4.0), 13 properties are being retained for further evaluation in the FS.

### 6.1.1 Identification of Contaminants of Potential Concern

Media-specific and property/area-specific COPCs being retained for radiological and/or metals dose/risk evaluations were identified in Section 4.0 through comparisons with the screening levels that are presented in Table 4-1. Radiological COPCs collectively include the following radionuclides associated with past MED/AEC operations: Ac-227, Pa-231, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-235, and U-238. Uranium-ore-related metals were identified as COPCs in inaccessible soil for each property/area located within the uranium-ore processing area presented on Figure 1-2, as well as within each soil borehole adjacent to a sewer line, based on exceedances of risk-based screening levels. Metals in sewer line sediments and in soil adjacent to sewer lines that served plants and buildings within the uranium-ore processing area were evaluated as COPCs, even if the sampling locations were outside of the uranium ore-processing area.

The following items summarize radiological and metal COPCs identified for each type of ISOU medium:

- Radionuclides and/or arsenic were identified as COPCs in soil that is inaccessible due to the presence of buildings and other permanent structures, including the subsoil within the footprint of a structure of which remediation would reasonably be expected to affect the stability of the structure. The COPCs identified for this type of inaccessible soil are presented below by property:

- Plant 1 – radionuclides,
- Plant 2 – radionuclides,
- St. Louis City Property (DT-2) – radionuclides,
- Gunther Salt (DT-4) North– radionuclides,
- Heintz Steel (DT-6) – radionuclides,
- PSC Metals, Inc. (DT-8) – radionuclides, and
- Thomas and Proetz Lumber Company (DT-10) - arsenic.

- Radionuclides, arsenic, and/or cadmium were identified as COPCs in soil located under active RRs, including the supporting soil in the associated ROW as summarized below:
  - Norfolk Southern RR (DT-3) – radionuclides,
  - Terminal RR (DT-9) Main Tracks – radionuclides and cadmium,
  - Terminal RR (DT-9) Rail Yard - radionuclides,
  - Terminal RR Soil Spoils Area - radionuclides, and
  - BNSF RR (DT-12) – radionuclides and arsenic.
- Radionuclides were identified as COPCs in soil located under the roadways listed below, which include the supporting soil in the associated ROWs. Roadways are defined as the public and private streets. It should be noted that this type of inaccessible soil does not include soil beneath driveways, parking lots, or other paved surfaces that were addressed as accessible soil areas.
  - Hall Street (West of Plant 6),
  - North Second Street (West of Plant 1),
  - Mallinckrodt Street (North of Plant 2),
  - Destrehan Street (West of Hall Street), and
  - Angelrodt Street (South of Plant 7S).
- Radionuclides were identified as COPCs in soil on the exteriors of the following buildings and permanent structures:
  - Building 25 at Plant 1,
  - Wood Storage Building at Thomas and Proetz Lumber Company (DT-10), and
  - horizontal beam between L-shaped building and brick warehouse at Cotto-Waxo Company (DT-14).
- Radionuclides, arsenic, cadmium and lead were identified as COPCs in soil adjacent to sewers in the following properties that were not directly encountered within an excavation area during the remedial action conducted under the 1998 ROD:
  - Plant 1 – radionuclides, arsenic, cadmium, and lead,
  - Plant 2 – radionuclides and lead,
  - Plant 6 – radionuclides (sewer line excavation) and lead,
  - St. Louis City Property (DT-2), Sewer Line beneath the Levee – radionuclides, and
  - Plant 7N/BNSF RR – radionuclides (Sewer Line beneath RR Tracks) and cadmium.
- Additionally, metal COPCs were identified in sediment samples collected from inside of sewer manholes at the following properties:
  - Plant 1 – Various Sewer Sediment Locations (arsenic and cadmium),

- Plant 2 – Various Sewer Sediment Locations (arsenic),
- Plant 6 – Sewer Sediment Locations (arsenic), and
- Illinois DOT and Missouri DOT (DT-11) – Sewer Sediment Location (arsenic).

Table 4-8 presents properties and areas that exceed screening levels, along with the COPCs that are evaluated in the HHRA.

### 6.1.2 Exposure Assessment and Results of the Dose and Risk Characterization

A CSM for the ISOU was presented and discussed in Section 5.0 and Figure 5-1. The CSM presented complete and incomplete exposure pathways identified for ISOU media and receptors under current configurations. This included contaminant sources, release/transport mechanisms, exposure media, and exposure routes that comprise the exposure pathways. Under current configurations (i.e., per Figure 5-1), the only potential exposure route for inaccessible soil contaminants beneath consolidated ground cover (e.g., buildings and pavement) is external radiation. For inaccessible soil beneath unconsolidated cover or no cover, ingestion, dermal contact, and external radiation could occur. Exposures to contaminated soil on building surfaces could occur via ingestion, inhalation and external radiation. Exposures to sediment inside of manholes and sewer lines could occur via ingestion and dermal contact. Finally, exposures to inaccessible soil adjacent to sewer lines can occur via ingestion, dermal contact, inhalation of dusts, and external radiation.

The focus of this RI is the assessment of the previously-described ISOU media. However, as discussed later in Section 6.2.2.1, this HHRA evaluates property-wide dose and risk for inaccessible soil, and inaccessible and accessible soil, combined, at each property, as necessary, as well as an individual assessment of specific elevated areas of inaccessible soil. The results of property-specific COPC identifications and the exposure assessment were combined with radiological and chemical toxicity criteria to calculate: 1) dose and CRs for receptor exposures to radiological COPCs, and 2) CRs and non-cancer HIs for exposures to metal COPCs. The resulting doses, CRs, and HIs were compared to a dose limit of 25 mrem/yr, a CR of 1.0E-05, and an HI of 1.0. Exceedances of dose/risk criteria indicate the need for further evaluations.

Lead was identified as a COPC for several sewer soil locations within the Plants 1, 2, and 6WH properties based on exceedances of the industrial screening level, which corresponds to USEPA's (2011a) industrial soil RSL. This RSL is based on the USEPA risk reduction goal for an occupational scenario to protect the fetus of a pregnant adult female worker from exposures that could result in the probability of the fetal blood lead concentration from exceeding 10 micrograms per deciliter (µg/dL) to no greater than 5% of the population. Therefore, to evaluate the potential for blood lead concentrations to exceed 10 at the ISOU, individual inaccessible soil sample concentrations observed at the elevated sewer soil locations have been compared to USEPA's (2011a) industrial RSL of 800 mg/kg. It is assumed that a screening level protective of a fetus will also afford protection for male and female adult workers. The exceedance of the industrial RSL by at least one sample concentration of lead at a property/area results in that property/area being retained for further evaluation in the FS.

The following subsections (Sections 6.1.2.1 through 6.1.2.5) summarize the manner in which exposure point concentrations (EPCs) were derived and receptor scenarios were evaluated for all of types of inaccessible soil, along with sewer sediment, that were previously described in Section 6.1.1. Additionally, Sections 6.1.2.1 through 6.1.2.5 summarize the findings of the dose and risk characterizations performed for each of the associated scenarios. Table 6-1 summarizes the property-specific receptor scenarios evaluated in the HHRA. Detailed descriptions of EPC derivations, receptor scenarios, and dose and risk characterization are provided in Appendix K.

#### *6.1.2.1 Inaccessible Soil Associated with Buildings, Structures, Railroads, and Roadways*

Property-wide evalutions of soil dose and risk are assessed in the HHRA as a two-tiered process. For each property, the Tier 1 evaluation first estimates dose and risk to all inaccessible soil areas. If the dose and risk estimated for inaccessible soil at a property exceeds target criteria, the Tier 2 assessment is performed that is inclusive of both inaccessible and accessible soil. In order to facilitate this evaluation, it is assumed that all inaccessible soil at each property has become accessible, so that inaccessible and accessible soil can be assessed under one consistent set of (accessible) exposure scenarios. As shown in Figure 6-1, following identification of COPCs, EPCs are calculated for all inaccessible soil for each property under the Tier 1 evaluation. Generally, the EPC is determined as the lesser of the 95% UCL and the maximum detected concentration. For evaluating radiological exposures, the mean background concentration was subtracted from the lesser of the 95% UCL and maximum detected concentration to determine the radiological EPC. Contrary to the EPC methodology for radionuclides, and for consistency with USEPA (1989a) risk assessment guidance, the background concentration was not subtracted from the lesser of the 95% UCL and maximum detected concentration to determine the EPC for each metal COPC. The EPCs for the property-wide inaccessible soil areas were then applied to the following receptor scenarios for quantitative dose and risk evaluations in the HHRA:

- Industrial Worker (All Plant Properties, Industrial/Commercial VPs, Railroad VPs and Roadways)
    - incidental ingestion of inaccessible soil,
    - dermal contact with inaccessible soil,
    - external gamma exposures from inaccessible soil, and
    - inhalation of particulate dust emissions from inaccessible contaminated soil.
- Construction Worker (Railroad VPs and Roadways)
    - incidental ingestion of inaccessible soil,
    - dermal contact with inaccessible soil,
    - external gamma exposures from inaccessible soil, and
    - inhalation of particulate dust emissions from inaccessible contaminated soil.
- Recreational User at St. Louis City Property (DT-2)
    - external gamma exposures from inaccessible soil excavated from beneath the St. Louis City Property, and
    - ingestion of inaccessible soil and inhalation of particulate dust emissions from inaccessible contaminated soil exposed from beneath the St. Louis City Property.

All radiological and metal EPCs for the above industrial and construction worker scenarios are presented in Tables K-2A through K-3B. All radiological EPCs for the recreational user scenario are presented in Table K-5. For consistency with the 1998a ROD (USACE 1998a), the industrial worker is a SLDS plant/VP employee assumed to work indoors 1600 hours/year (200 days/year) and also performs light excavation/construction work outdoors for an additional 400 hours/year (50 days/year). An additional 125 hours is assumed for the indoor time fraction to account of the possibilities of early arrivals to work, having lunch on-site, and late departures. The construction worker is assumed to be a contractor (i.e., not a SLDS plant/VP employee) who performs one-time, deep excavation and construction activities at the ISOU, at a frequency of 90 days per year over a one-year duration. The recreational user at the St. Louis City Property (DT-2) is assumed to be an adolescent, (ages 10 to 18 years) who uses the St. Louis Riverfront Trail along the levee for walking, jogging, and biking. Of the three receptor scenarios, the industrial worker is considered to be the limiting receptor that determines the dose and risk status of each

**Table 6-1. Property and Media-Specific Receptor Scenarios for Evaluation in the Human Health Risk Assessment**

| Property | ISOU Media: | Inaccessible Soil (Assumed to be Accessible) | | | | Building/ Structural Surfaces | Sewers | |
|---|---|---|---|---|---|---|---|---|
| | Receptor: | Industrial Worker | Construction Worker | Utility Worker | Recreational User at City Property | Industrial Worker | Utility Worker (Soil Adjacent to Sewers) | Sewer Maintenance Worker (Sediment) |
| | Areas/Buildings Exceeding Screeing Levels (Section 4.0) | | | | | | | |
| Plant 1 | Building 25 | | --- | Radiological[a] | --- | Radiological[a] | --- | --- |
| | Area Beneath Building 26 | | --- | Radiological[a] | --- | --- | --- | --- |
| | Two Areas Beneath Building X | | --- | Radiological[a] | --- | --- | --- | --- |
| | Four Areas at Building 8 | Radiological[a,b] | --- | Radiological[a] | --- | --- | --- | --- |
| | Three Inaccessible Soil Areas Adjacent to Building K Excavation Area | | --- | Radiological[a] | --- | --- | --- | --- |
| | Inaccessible Soil Area North of Southeast Containment Pad | | --- | Radiological[a] | --- | --- | --- | --- |
| | Inaccessible Soil Area South of Building X Loading Dock | | --- | Radiological[a] | --- | --- | --- | --- |
| | Sewer Sediment Locations | --- | --- | --- | --- | --- | --- | As, Cd |
| | Sewer Borehole Between Buildings G and 17 | --- | --- | --- | --- | --- | Radiological[a], As, Cd, Pb | --- |
| Plant 2 | Building 508 | | --- | Radiological[a] | --- | --- | --- | --- |
| | Area at North End of 50-Series Building Excavation | | --- | Radiological[a] | --- | --- | --- | --- |
| | Inaccessible Soil Area North of Building 510 (and South of the 50-Series Buildings Excavation). | Radiological[a, b] | --- | Radiological[a] | --- | --- | --- | --- |
| | Southeast Corner | | --- | Radiological[a] | --- | --- | --- | --- |
| | Sewer Sediment Locations | --- | --- | --- | --- | --- | --- | As |
| | Sewer Borehole Locations | --- | --- | --- | --- | --- | Pb | --- |
| Plant 6 | Inaccessible Areas at the Southwest Corner Adjacent to Destrehan Street | Radiological[a,b] | --- | Radiological[a] | --- | --- | --- | --- |
| | Along Hall Street, West of Plant 6[c] | | --- | Radiological[a] | --- | --- | --- | --- |
| | Sewer Sediment Locations | --- | --- | --- | --- | --- | --- | As |
| | Sewer Beneath Hall Street at Northwest Corner of Plant 6WH | --- | --- | --- | --- | --- | Radiological[a] | --- |
| | Soil Location South of Plant 6W Adjacent to Sewer Line | --- | --- | --- | --- | --- | Pb | --- |
| City of St. Louis Property (DT-2) | Levee South Area (East of Adjacent Plant 7E and DT-1) | Radiological[a,b] | --- | Radiological[a] | Radiological[a,b] | --- | --- | --- |
| | Levee Area Just South of McKinley Bridge | | --- | Radiological[a] | | --- | --- | --- |
| | Sewers Beneath the Levee | --- | --- | --- | --- | --- | Radiological[a] | --- |
| Gunther Salt North (DT-4) | Salt Dome Area and Northeast Corner of Southern Storage Building | | --- | Radiological[a] | --- | --- | --- | --- |
| | Southern Storage Building | Radiological[b, c] | --- | Radiological[a] | --- | --- | --- | --- |
| | Sidewalk along Buchanan Street | | --- | Radiological[a] | --- | --- | --- | --- |
| | Areas Within and Adjacent to Administration/Warehouse Building | | --- | Radiological[a] | --- | --- | --- | --- |
| Heintz Steel (DT-6) | Areas Beneath Storage Building | Radiological[b, c] | --- | Radiological[a] | --- | --- | --- | --- |
| | Inaccessible Area at Western Edge of Storage Building Along Hall Street | | --- | Radiological[a] | --- | --- | --- | --- |
| PSC Metals, Inc. (DT-8) | North Tract 3 – RR Tracks Area | | --- | Radiological[a] | --- | --- | --- | --- |
| | North Tract 4 - RR Tracks Area | Radiological[b, c] | --- | Radiological[a] | --- | --- | --- | --- |
| | South Tract – Southeast Corner of Warehouse | | --- | Radiological[a] | --- | --- | --- | --- |

**Table 6-1. Property and Media-Specific Receptor Scenarios for Evaluation in the Human Health Risk Assessment**

| Property | ISOU Media: | Inaccessible Soil (Assumed to be Accessible) | | | | Building/ Structural Surfaces | Sewers | |
|---|---|---|---|---|---|---|---|---|
| | Receptor: | Industrial Worker | Construction Worker | Utility Worker | Recreational User at City Property | Industrial Worker | Utility Worker (Soil Adjacent to Sewers) | Sewer Maintenance Worker (Sediment) |
| | Areas/Buildings Exceeding Screeing Levels (Section 4.0) | | | | | | | |
| Thomas and Proetz Lumber Company (DT-10) | Property-Wide | As | --- | --- | --- | --- | --- | --- |
| | Wood Storage Building | --- | --- | --- | --- | Radiological[a] | | |
| | Office Building | --- | --- | As | --- | --- | --- | --- |
| McKinley Bridge (DT-11) | Sewer Sediment Locations | --- | --- | --- | --- | --- | --- | As |
| Cotto-Waxo Company (DT-14) | Horizontal Beam between L-Shaped Building and Brick Warehouse | --- | --- | --- | --- | Radiological[a] | --- | --- |
| Norfolk Southern RR (DT-3) | Elevated Measurement Areas between Mallinckrodt and Angelrodt Streets | Radiological[a,b] | Radiological[a,b] | Radiological[a,b] | --- | --- | --- | --- |
| Terminal RR Association (DT-9) Rail Yard | Three Areas in the Rail Yard (Two on the Northern RR Track and One on the RR Track Traversing Southwest to Northeast) | Radiological[a] | Radiological[a] | Radiological[a] | --- | --- | --- | --- |
| Terminal RR Association (DT-9) Main Tracks | Three Areas Between McKinley Bridge and Destrehan Street | Radiological[a], Cd | Radiological[a], Cd | Radiological[a], Cd | --- | --- | --- | --- |
| Terminal RR Association Soil Spoils Area | Small Area at the Southern End of the Norfolk Southern RR Spur in the Northern Portion of the Property, and Two Isolated Areas Along the Terminal RR Tracks | Radiological[a] | Radiological[a] | Radiological[a] | --- | --- | --- | --- |
| BNSF RR (DT-12) | One Area North of McKinley Bridge, East and adjacent to DT-9 Rail Yard | Radiological[a,b], As | Radiological[a,b], As | Radiological[a,b], As | --- | --- | --- | --- |
| | Large Area on the West side of Tracks Extending from Just North of Destrehan Street South to Dock Street | | | | --- | --- | --- | --- |
| | Sewers Northeast of Plant 7N that Extend Beneath BNSF RR tracks | --- | --- | --- | --- | --- | Radiological[a], | --- |
| Hall Street | West of Plant 6[c] | Radiological[a] | Radiological[a] | Radiological[a] | --- | --- | --- | --- |
| North Second Street | West of Plant 1 | Radiological[a] | Radiological[a] | Radiological[a] | --- | --- | --- | --- |
| Mallinckrodt Street | North of Plant 2 | Radiological[a] | Radiological[a] | Radiological[a] | --- | --- | --- | --- |
| Destrehan Street | West of Hall Street | Radiological[a] | Radiological[a] | Radiological[a] | --- | --- | --- | --- |
| Angelrodt Street | South of Plant 7S | Radiological[a] | Radiological[a] | Radiological[a] | --- | --- | --- | --- |

Note: Receptor scenarios evaluated in this BRA and are the basis for determination of exposure point concentrations are shaded gray.

[a] Radiological COPCs were identified by exceedance of $SOR_N > 1.0$, and always include the following: Ac-227, Pa-231, Ra-226, radium-228 (Ra-228), thorium-228 (Th-228), Th-230, Th-232, U-235, and U-238. Metals were only identified as COPCs if they exceed the industrial risk-based screening level and are commingled with radiological contamination in at least one sampling location. Dashes indicate no COPCs are identified for the area and medium.

[b] Multiple specific locations are combined as shown into one property-wide exposure area for evaluation of dose and risk. Industrial/construction worker exposure areas are combined property-wide; utility worker exposure areas are combined to include areas around elevated locations.

[c] Elevated area on western border of Plant 6 is being evaluated for both Plant 6 and Hall Street

"---" = No risk evaluation being performed for receptor at the identified property.

As - Arsenic

Cd - Cadmium

Pb - Lead

property/area and the need for further evaluation in the CERCLA process. This is because of the greatest frequency of soil exposures assumed for the industrial worker. Therefore, the two-tiered evaluation process is applied primarily to the industrial worker. Additionally, a recreational user at the St. Louis City Property (DT-2) is evaluated using the two-tiered process as a conservative measure to determine potential property-wide doses and risks associated mainly with users of the St. Louis Riverfront Trail. Both tiers of evaluation are applied to the recreational user regardless of target dose or risk level exceedances.

Because the HHRA assumes that property-wide inaccessible soil has become accessible, the cover depth (i.e., the thickness of ground cover between the receptor and the top of the contaminated zone) is assumed to be zero meters for the industrial worker and construction worker. However, for the recreational user, the cover is comprised of levee material; therefore, a cover depth of one meter is assumed for the recreational user, based on the shallowest radiological screening level exceedance. Exposure assumptions for these receptors are presented for radiological and metals evaluations in Tables K-9 and K-11, respectively.

Radiological doses and risks for inaccessible soil were determined using the RESRAD model. If the dose or risk for inaccessible soil at a specific property exceeds the criterion for the industrial worker, the Tier 2 evaluation is performed in which property-wide EPCs are calculated using inaccessible data from this RI, combined with the accessible data from previous investigations, in order to generate a true property-wide dose and risk evaluation (See Appendix K, Section K2.3.2.1 for details). The Tier 2 radiological and metal EPCs are presented for the industrial worker in Tables K-15A and K-15B, respectively. Once calculated, the property-wide EPCs are applied to the industrial worker and recreational user at the St. Louis City Property (DT-2) scenarios described above. In addition to the industrial worker Tier 1 evaluation, a construction worker scenario was evaluated for the RR properties and roadways, and a recreational user was evaluated for the St. Louis City Property (DT-2). The construction worker scenario was evaluated for only inaccessible soil exposures, independent of the two-tiered evaluation. As fully described in Appendix K, a total of 16 properties were originally assessed for inaccessible soil under the Tier 1 evaluation for radiological and/or metal dose and risk. Following the Tier 1 and 2 evaluations of the industrial worker scenario, it is determined that the dose and risk for 3 properties meet target criteria [Plant 2; PSC Metals, Inc. (DT-8); and Thomas and Proetz Lumber (DT-10)]. Additionally, both the Tiers 1 and 2 dose and risk estimated for the recreational user at the St. Louis City Property (DT-2) are less than target criteria, though the industrial worker risk exceeds the target risk criterion. The following 13 properties are associated with dose and/or risk that exceeded target criteria and are therefore, being retained for further evaluation in the FS (the three portions of the Terminal RR are considered to be one property):

- Inaccessible Soil at Plant Properties and Industrial/Commercial VPs:
  - Plant 1 – Radiological COCs
  - Plant 6 – Radiological COCs
  - St. Louis City Property (DT-2) – Radiological COCs
  - Gunther Salt (DT-4) North – Radiological COCs
  - Heintz Steel (DT-6) – Radiological COCs
- Inaccessible Soil at Railroad Properties:
  - Norfolk Southern RR (DT-3) – Radiological COCs
  - Terminal RR (DT-9) Main Tracks – Radiological COCs
  - Terminal RR (DT-9) Rail Yard – Radiological COCs
  - Terminal RR Soil Spoils Area – Radiological COCs
  - BNSF RR (DT-12) – Radiological COCs and arsenic

- Inaccessible Soil at Roadways:
  - Hall Street (West of Plant 6) – Radiological COCs
  - North Second Street (West of Plant 1) – Radiological COCs
  - Mallinckrodt Street (North of Plant 2) – Radiological COCs
  - Destrehan Street (West of Hall Street) – Radiological COCs
  - Angelrodt Street (South of Plant 7S) – Radiological COCs

*6.1.2.2 Soil in Elevated Measurement Areas*

Properties are evaluated in the HHRA because of the presence of radiological and metal concentrations above screening levels. Areas containing screening level exceedances are referred to as elevated measurement areas. Because it is possible that a property-wide HHRA can show no dose or risk above target criteria, even though elevated measurement areas are present on the property, all elevated measurement areas are evaluated independently in this HHRA using the utility worker scenario. Consistent with the methodology and assumptions in the 1998 FS and ROD (USACE 1998b and 1998a, respectively), a utility worker is assumed to perform one-time work (e.g., on utilities) within deep excavations with those areas, for a short time duration (80 hours or ten 8-hour days). An EPC has been calculated for each COPC based on the lesser of the 95% UCL and maximum detected concentration determined from all samples collected from within the area. All EPCs estimated for radiological and metal COPCs are presented in Tables K-4A and K-4B, respectively. The following summarizes the exposure scenario evaluated for elevated areas at all properties:

- Utility Worker (All Plant Properties, Industrial/Commercial VPs, Railroad VPs and Roadways)
  - incidental ingestion of inaccessible soil,
  - dermal contact with inaccessible soil,
  - external gamma exposures from inaccessible soil, and
  - inhalation of particulate dust emissions from excavated inaccessible contaminated soil.

Exposure assumptions for this receptor are presented for radiological and metals evaluations in Tables K-9 and K-11, respectively. As fully described in Appendix K, 35 elevated measurement areas are evaluated in the HHRA. Of the 35 areas evaluated, the dose and risk for 34 areas meet target criteria. The following property/area had dose and risk that exceeded target criteria and is being retained for further evaluation in the FS:

- Inaccessible Soil in Elevated Measurement Areas:
  - Plant 1, Building 26 – Radiological COCs

*6.1.2.3 Soil on Surfaces of Buildings and Structures*

During renovation/demolition activities involving existing structures, industrial workers could directly contact and potentially become exposed to radiologically contaminated surfaces. Based on the results of the building surveys, three buildings within the SLDS ISOU were found to have exterior surfaces that exhibited gross alpha activities exceeding the screening level of 3,900 dpm/100 $cm^2$. Potential exposures to these surfaces are assumed to occur throughout the duration of a typical renovation/construction project, which would likely be a once in a lifetime event for an industrial worker (SLDS/VP employee), lasting 30 days.

EPCs for building and structural surfaces are calculated as the lesser of the 95% UCL and maximum gross alpha measurement, and converted to the unit of picocuries per square meter ($pCi/m^2$). Individual radionuclide-specific EPCs were calculated by multiplying the gross alpha value (lesser of the 95% UCL and maximum gross alpha) by the radionuclide-specific activity fractions for SLDS soil (see Table K-6A), as obtained from the 1993 BRA (DOE 1993). Building/structural surface EPCs for this HHRA are presented in Table K-6B.

The HHRA scenario for evaluating future industrial worker exposures to radiological COPCs in soil on contaminated exterior building surfaces is summarized below:

- Industrial Worker (Exterior Building/Structural Surfaces)
  - incidental ingestion of soil on building/structural surfaces,
  - inhalation of particulate dust emissions from building/structural surfaces, and
  - external gamma exposures.

Radiological dose and risk for buildings/structures were calculated by entering the surface EPC and the exposure assumptions into the RESRAD-Build model. All exposure assumptions used as model inputs are presented in Table K-10.

None of the exterior surfaces of the 3 buildings/structures evaluated in the HHRA exceed dose or risk criteria. Therefore, none of the evaluated buildings are being retained for further evaluation in the FS.

#### *6.1.2.4 Sediment in Sewer Lines*

As discussed previously in Section 6.2.1, only metal COPCs (arsenic and cadmium) were identified in sewer sediment. Because only one sample was collected from each location, EPCs are represented by the measured sample concentrations reported for each COPC at each location. All metal EPCs for sewer sediment are presented in Table K-7.

During infrequent maintenance work on the interiors of manholes and sewer lines (assumed to be one day per year over 25 years), the potential exists for ingestion and dermal exposures to metal COPCs in sediment. Maintenance worker inhalation exposures to sediments are not likely to occur via the generation of particulate emissions during work activities due to the high moisture content that is characteristic of sediment. The HHRA scenario for evaluating sewer maintenance worker exposures to metal COPCs in sewer sediment is summarized below:

- Sewer Maintenance Worker (Sediments in Sewer Lines)
  - incidental ingestion of contaminated sediment in sewers, and
  - dermal contact with contaminated sediment in sewers.

All exposure assumptions for this receptor are presented in Table K-11.

No dose or risk criteria exceedances have been estimated for sediment inside of sewer lines; therefore, none of the sewers are being retained for further evaluations of sediments in the FS.

#### *6.1.2.5 Soil Adjacent to Sewer Lines*

Radiological and metals COPCs (arsenic, cadmium, and lead) were identified at specific sampling locations within the properties identified in Section 6.2.1; therefore, EPCs were determined for each sampling location. Because two or three depth intervals were sampled per soil location, and because 95% UCLs cannot be determined for only two or three samples, the EPC for each soil location is represented by the maximum detected concentration at each location (minus background for radiological evaluations). The lesser of the UCL and maximum detection was used as the EPC for each sewer excavation area. All radiological and metal EPCs determined for inaccessible soil locations adjacent to sewer lines are presented in Tables K-8A and K-8B, respectively.

In the HHRA, it is assumed that direct contact with inaccessible soil at locations adjacent to sewer lines can only occur to individuals when excavation is performed (e.g., during removal/replacement of sewer lines). During an excavation scenario, the utility worker is assumed to be the most likely individual who could become exposed to small localized areas of inaccessible soil. Therefore, the HHRA scenario for evaluating sewer utility worker exposures to radiological and metal COPCs in soil adjacent to sewer lines is summarized below:

- Sewer Utility Worker (Inaccessible Soil Adjacent to Sewer Lines)
  - incidental ingestion of inaccessible soil,
  - dermal contact with inaccessible soil,
  - external gamma exposures from inaccessible soil, and
  - inhalation of particulate dust emissions from excavated inaccessible contaminated soil.

Assumptions and RESRAD model inputs used for evaluating sewer utility worker exposures to radiological and metals COPCs in inaccessible soil adjacent to sewer lines are presented in Tables K-9 and K-11. As fully described in Appendix K, 6 soil borehole locations and three areas of sewer excavations were evaluated in the HHRA. The dose and risk estimated for radiological and metal COPCs at all of the borehole locations are below target criteria; however lead concentrations exceed the screening level of 800 mg/kg at 4 of the 6 boreholes evaluated in the HHRA. Additionally, radiological dose and/or risk at all three of the sewer excavation areas exceed target criteria. Therefore, the following soil borehole locations and sewer excavation areas are being retained for further evaluation in the FS:

- Inaccessible Soil Adjacent to Sewer Lines:
  - Plant 1, Boreholes SLD124540 (Radiological COCs and Lead), SLD124560 (Lead), and SLD124570 (Lead)
  - Plant 2, Borehole SLD124576 – Lead
  - Plant 6, Sewer Line in Northwest Corner of Property, beneath Hall Street (excavation sidewall data used) – Radiological COCs
  - Plant 6, Borehole SLD127572 – Lead
  - St. Louis City Property (DT-2), Sewer Line beneath the Levee – Radiological COCs
  - Plant 7N/BNSF RR (DT-12) Sewer Line beneath the RR Tracks – Radiological COCs

## 6.2 ECOLOGICAL ASSESSMENT

A qualitative ecological assessment was conducted based on the results, findings, and recommendations of the environmental assessment of biota conducted for accessible media in 1993 (DOE 1993), as well as on the findings of a September 10, 2010, site visit, which were used to complete USEPA's Ecological Checklist regarding the environmental setting, potential receptors, contaminant fate and transport, and exposure pathways. The checklist is presented as Appendix R.

The ecological risk assessment included a description and comparison of pre- and post-1993 ecological risk assessment guidance, with the focus being on USEPA's (1989b) RAGS Volume 2 and the current USEPA Ecological Risk Assessment Guidance for Superfund (ERAGS) (1997c). The comparison concluded that many of the evaluation methods established under USEPA's (1989b) RAGS Volume 2 are also part of the current guidance. However, the current guidance provides more structure to the original process by employing a step-by-step ecological risk assessment approach. Many of the methods and definitions presented in the current USEPA ERAGS (1997c) are consistent with those in RAGS Volume 2 (USEPA 1989b). Another difference between guidance documents is that the current ERAGS applies a quantitative approach toward calculating risk that determines an ecological hazard quotient.

Based on this information and the findings from site visit, as documented in Appendix R, USACE concurs with the findings of the 1993 ecological evaluation that potential impacts to ecological receptors from accessible environmental media at the SLDS are likely to be insignificant, because the SLDS is a heavily urbanized area not suitable for habitation of sensitive and threatened and endangered (T&E) species. Therefore, potential impacts from ISOU media are likely to be even less significant than impacts from accessible media for the following reasons: (1) it is highly unlikely that potential ecological impacts from the ISOU are greater than those from accessible media, (2) the potential for direct exposures to ISOU media is greater for humans than for terrestrial or aquatic species, and (3) the potential for subsurface migration beneath structures to sensitive terrestrial or aquatic habitats (although none are likely to exist) is unlikely. Also, given that some remediation at the SLDS has since been conducted, potential impacts to ecological resources from the ISOU contaminated media are likely to be even less significant than those determined during the 1993 BRA. It is for the aforementioned reasons that the ISOU BRA does not include a comprehensive ecological risk assessment.

## 6.3 SUMMARY

As described above and detailed in Appendix K, a comprehensive HHRA was completed based on the identification of radiological and metal COPCs in Section 4.0. The following six general receptor/property scenarios and the associated data sets were evaluated:

- industrial worker exposed to property-wide inaccessible soil,
- industrial worker exposed to property-wide inaccessible and accessible soil (combined),
- construction workers exposed to property-wide inaccessible soil at RR properties and roadways,
- utility workers exposed to inaccessible soil at elevated measurement areas and soil locations adjacent to sewer lines,
- recreational users exposed to inaccessible soil at the St. Louis City Property (DT-2),
- industrial workers exposed to radiologically contaminated soil on exterior building/structural surfaces, and
- sewer maintenance workers exposed to sediment inside of sewer lines.

All dose and risks results for the above scenarios are presented in Tables 6-2, 6-3, and 6-4 for inaccessible soil, soil on exterior surfaces of buildings or structures, sewer sediment, and inaccessible soil adjacent to sewer lines, respectively.

A two-tiered HHRA process was applied to the evaluations of soil dose and risk at each property. The first conservative step in the process (i.e., Tier 1 evaluation) was the assumption that the inaccessible soil would become accessible at some point in the future to industrial worker at all properties; therefore, no cover was assumed. In addition to the industrial worker, RR properties and roadways were evaluated using a construction worker scenario, and the St. Louis City Property (DT-2) was evaluated using a recreational user scenario. Properties exceeding dose or risk target criteria for inaccessible soil during the Tier 1 evaluations were then retained for the Tier 2 evaluation, which involved evaluation of property-wide industrial worker exposures to combined inaccessible and accessible soil. The recreational user at the St. Louis City Property (DT-2) was retained for Tier 2 regardless of the dose or risk results. The construction worker scenario was evaluated for only inaccessible soil exposures at the RR properties and roadways, independent of the two-tiered evaluation process. Appendix K, Section K2.3.2.1 discusses in greater detail, the two-tiered property-wide evaluation approach. Based on the property-wide HHRA results, 13 properties (including 2 plant properties, the St. Louis City Property, 2 industrial/commercial VPs, 3 RRs, and 5 roadways) of the 16 properties evaluated in the HHRA had dose and/or risk that exceeded target criteria and are being retained for further evaluation in the FS.

In addition to the property-wide evaluations, individual elevated measurement areas of inaccessible soil were evaluated assuming utility worker would be actively working in the contaminated zone for the entire exposure period. Only 1 elevated measurement area (Plant 1, Building 26) out of the 35 areas evaluated, is being retained for further evaluation in the FS.

None of the 3 buildings/structures evaluated for radiologically contaminated soil on exterior surfaces exceeded dose or risk target criteria; therefore, no buildings/structures are being further evaluated in the FS.

For sewers, sewer line sediment samples did not exceed screening levels and were not evaluated for in the HHRA for dose and risk; therefore, sediment inside of sewer lines is not being retained for evaluation in the FS. The HHRA evaluated dose and risk for soil adjacent to sewer lines at 6 borehole locations and three areas of sewer excavations. The dose and risk estimated for radiological and metal COPCs at all of the borehole locations are below target criteria; however lead concentrations exceed the screening level of 800 mg/kg at 5 boreholes evaluated in the HHRA (4 boreholes of which were not evaluated for risk and/or dose). Additionally, radiological dose and/or risk at all three of the sewer excavation areas exceed target criteria. Therefore, lead concentrations at the four soil boreholes and radiological contamination at all three sewer excavation areas evaluated are being retained for further evaluation in the FS.

Based on the findings from site visit that occurred during the RI, as documented in Appendix R, along with the findings of the 1993 ecological evaluation (DOE 1993), potential impacts to ecological receptors from ISOU media at the SLDS are likely to be insignificant.

Table 6-2. Summary of Risk Characterizaton Results for Inaccessible Soil and Soil on Exterior Surfaces of Buildings and Structures[a]

| Property | ISOU Media: | Inaccessible Soil (Assumed to be Accessible) | | | | | | | | | | | | | | Building/ Structural Surfaces | | Combined Accessible and Inaccessible Soil | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Receptor: | Industrial Worker (Plants, Industrial/Commerical VPs, Railroads, Roadways) | | | | Construction Worker (Railroads and Roadways) | | | | Utility Worker (Elevated Measurement Areas) | | | | Recreational User at City Property | | Industrial Worker (Exterior Surfaces) | | Industrial Worker (Plants and Industrial/Commerical VPs) | | | | Recreational User at City Property | |
| | Areas/Buildings Exceeding Screeing Levels (Section 4.0) | Rad. Dose (mrem/yr) | Rad. CR | Metals CR | Metals HI | Rad. Dose (mrem/yr) | Rad. CR | Metals CR | Metals HI | Rad. Dose (mrem/yr) | Rad. CR | Metals CR | Metals HI | Rad. Dose (mrem/yr) | Rad. CR | Rad. Dose (mrem/yr) | Rad. CR | Rad. Dose (mrem/yr) | Rad. CR | Metals CR | Metals HI | Rad. Dose (mrem/yr) | Rad. CR |
| Plant 1 | Building 25 | 31[b] | 5.4E-04[b] | --- | --- | --- | --- | --- | --- | 0.1 | 9.6E-08 | --- | --- | --- | --- | <0.1 | 5.7E-09 | 15 | 2.7E-04[b] | --- | --- | --- | --- |
| | Area Beneath Building 26 | | | | | --- | --- | --- | --- | 19 | 1.4E-05[b] | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| | Two Areas Beneath Building X | | | | | --- | --- | --- | --- | 2 | 1.0E-06 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| | Four Areas at Building 8 | | | | | --- | --- | --- | --- | 3 | 1.9E-06 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| | Three Inaccessible Soil Areas Adjacent to Building K Excavation Area | | | | | --- | --- | --- | --- | 3 | 1.9E-06 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| | Inaccessible Soil Area North of Southeast Containment Pad | | | | | --- | --- | --- | --- | 1 | 7.1E-07 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| | Inaccessible Soil Area South of Building X Loading Dock | | | | | --- | --- | --- | --- | 0.8 | 5.6E-07 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| Plant 2 | Building 508 | 2 | 2.9E-05[c] | --- | --- | --- | --- | --- | --- | 0.2 | 1.5E-07 | --- | --- | --- | --- | --- | --- | 0.8 | 9.9E-06 | --- | --- | --- | --- |
| | Area at North End of 50-Series Building Excavation | | | --- | --- | --- | --- | --- | --- | 0.7 | 4.3E-07 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| | Inaccessible Soil Area North of Building 510 (and South of the 50-Series Buildings Excavation) | | | --- | --- | --- | --- | --- | --- | 0.1 | 8.0E-08 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| | Southeast Corner | | | --- | --- | --- | --- | --- | --- | 1 | 9.9E-07 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| Plant 6 | Inaccessible Areas at the Southwest Corner Adjacent to Destrehan Street | 22 | 3.7E-04[b] | --- | --- | --- | --- | --- | --- | 4 | 2.5E-06 | --- | --- | --- | --- | --- | --- | 3 | 4.9E-05[b] | --- | --- | --- | --- |
| | Along Hall Street, West of Plant 6[d] | | | --- | --- | | | --- | --- | 1 | 6.9E-07 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| City of St. Louis Property (DT-2) | Levee South Area (East of Adjacent Plant 7E and DT-1) | 3 | 6.1E-05[b] | --- | --- | --- | --- | --- | --- | 0.7 | 4.8E-07 | --- | --- | <0.1 | 1.2E-11 | --- | --- | 2 | 3.3E-05[c] | --- | --- | <0.1 | 5.4E-12 |
| | Levee Area Just South of McKinley Bridge | | | --- | --- | --- | --- | --- | --- | 0.3 | 2.3E-07 | --- | --- | | | --- | --- | | | --- | --- | | |
| Gunther Salt North (DT-4) | Salt Dome Area and Northeast Corner of Southern Storage Building | 48[c] | 8.4E-04[c] | --- | --- | --- | --- | --- | --- | 11 | 6.9E-06 | --- | --- | --- | --- | --- | --- | 28[c] | 4.9E-04[c] | --- | --- | --- | --- |
| | Southern Storage Building | | | --- | --- | --- | --- | --- | --- | 5 | 3.1E-06 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| | Sidewalk along Buchanan Street | | | --- | --- | --- | --- | --- | --- | 0.6 | 3.8E-07 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| | Areas Within and Adjacent to Administration/Warehouse Building | | | --- | --- | --- | --- | --- | --- | 0.4 | 2.5E-07 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| Heintz Steel (DT-6) | Areas Beneath Storage Building | 18 | 3.5E-04[c] | --- | --- | --- | --- | --- | --- | 1.8 | 1.2E-07 | --- | --- | --- | --- | --- | --- | 7 | 1.3E-04[c] | --- | --- | --- | --- |
| | Inaccessible Area at Western Edge of Storage Building Along Hall Street | | | --- | --- | --- | --- | --- | --- | 1 | 7.7E-07 | --- | --- | --- | --- | --- | --- | | | --- | --- | --- | --- |
| PSC Metals, Inc. (DT-8) | North Tract 3 – RR Tracks Area | 0.2 | 4.1E-06 | --- | --- | --- | --- | --- | --- | 0.1 | 8.2E-08 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | North Tract 4 - RR Tracks Area | | | --- | --- | --- | --- | --- | --- | 0.08 | 5.8E-08 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | South Tract – Southeast Corner of Warehouse | | | --- | --- | --- | --- | --- | --- | 2 | 1.1E-06 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Thomas and Proetz Lumher Company (DT-10) | Property-Wide | --- | --- | 2.7E-05 (Arsenic) | 1.7E-01 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 8.8E-06 | 5.5E-02 | --- | --- |
| | Wood Storage Building | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 0.1 | 1.6E-08 | --- | --- | --- | --- | --- | --- |
| | Office Building | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 5.8E-07 | 9.0E-02 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Cotto-Waxo Company (DT-14) | Horizontal Beam between L-Shaped Building and Brick Warehouse | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | <0.1 | 2.5E-09 | --- | --- | --- | --- | --- | --- |
| Norfolk Southern RR (DT-3) | Elevated Measurement Areas between Mallinckrodt and Angelrodt Streets | 2 | 3.0E-05[c] | --- | --- | 1 | 6.4E-06 | --- | --- | 1 | 6.8E-07 | --- | --- | --- | --- | --- | --- | 2 | 3.3E-05[c] | --- | --- | --- | --- |
| Terminal RR Association (DT-9) Rail Yard | Three Areas in the Rail Yard (Two on the Northern RR Track and One on the RR Track Traversing Southwest to Northeast) | 18 | 3.3E-04[b] | --- | --- | 9 | 6.3E-06 | --- | --- | 4 | 2.9E-06 | --- | --- | --- | --- | --- | --- | 4 | 6.7E-05[b] | --- | --- | --- | --- |
| Terminal RR Association (DT-9) Main Tracks | Three Areas Between McKinley Bridge and Destrehan Street | 2 | 4.1E-05[d] | 9.8E-10 | 2.5E-02 | 1 | 7.7E-07 | 7.1E-11 | 7.0E-02 | 1.8 | 1.4E-06 | 1.8E-11 | 1.8E-02 | --- | --- | --- | --- | 2 | 3.1E-05[d] | --- | --- | --- | --- |

**Table 6-2. Summary of Risk Characterizaton Results for Inaccessible Soil and Soil on Exterior Surfaces of Buildings and Structures[a]**

| Property | ISOU Media: | Inaccessible Soil (Assumed to be Accessible) | | | | | | | | | | | | | | Building/ Structural Surfaces | | Combined Acccessible and Inaccessible Soil | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Receptor: | Industrial Worker (Plants, Industrial/Commerical VPs, Railroads, Roadways) | | | | Construction Worker (Railroads and Roadways) | | | | Utility Worker (Elevated Measurement Areas) | | | | Recreational User at City Property | | Industrial Worker (Exterior Surfaces) | | Industrial Worker (Plants and Industrial/Commerical VPs) | | | | Recreational User at City Property | |
| | Areas/Buildings Exceeding Screeing Levels (Section 4.0) | Rad. Dose (mrem/yr) | Rad. CR | Metals CR | Metals HI | Rad. Dose (mrem/yr) | Rad. CR | Metals CR | Metals HI | Rad. Dose (mrem/yr) | Rad. CR | Metals CR | Metals HI | Rad. Dose (mrem/yr) | Rad. CR | Rad. Dose (mrem/yr) | Rad. CR | Rad. Dose (mrem/yr) | Rad. CR | Metals CR | Metals HI | Rad. Dose (mrem/yr) | Rad. CR |
| Terminal RR Association Soil Spoils Area | Small Area at the Southern End of the Norfolk Southern RR Spur in the Northern Portion of the Property, and Two Isolated Areas Along the Terminal RR Tracks | 18 | **3.3E-04[c]** | --- | --- | 9 | 6.4E-06 | --- | --- | 2 | 1.1E-06 | --- | --- | --- | --- | --- | --- | 4 | **5.3E-05[c]** | --- | --- | --- | --- |
| BNSF RR (DT-12) | One Area North of McKinley Bridge, East and adjacent to DT-9 Rail Yard | 2 | **2.9E-05[c]** | 2.7E-05 (Arsenic) | 1.7E-01 | 0.8 | 5.5E-07 | 6.2E-06 | 9.6E-01 | 0.2 | 1.3E-07 | 6.9E-07 | 1.1E-01 | --- | --- | --- | --- | 2 | **2.9E-05[c]** | --- | --- | --- | --- |
| | Large Area on the West side of Tracks Extending from Just North of Destrehan Street South to Dock Street | | | | | | | | | | | | | --- | --- | --- | --- | | | | | | |
| Hall Street | West of Plant 6[d] | 4 | **7.0E-05[b]** | --- | --- | 2 | 1.4E-06 | --- | --- | 0.5 | 3.1E-07 | --- | --- | --- | --- | --- | --- | 8 | **1.4E-04[b]** | --- | --- | --- | --- |
| North Second Street | West of Plant 1 | 2 | **3.1E-05[c]** | --- | --- | 0.9 | 5.8E-07 | --- | --- | 0.5 | 2.9E-07 | --- | --- | --- | --- | --- | --- | 2 | **4.2E-05[c]** | --- | --- | --- | --- |
| Mallinckrodt Street | North of Plant 2 | 1 | **2.0E-05[d]** | --- | --- | 0.5 | 3.9E-07 | --- | --- | 0.2 | 1.6E-07 | --- | --- | --- | --- | --- | --- | 1 | **1.4E-05[d]** | --- | --- | --- | --- |
| Destrehan Street | West of Hall Street | 7 | **1.3E-04[c]** | --- | --- | 3 | 2.4E-06 | --- | --- | 0.2 | 1.3E-07 | --- | --- | --- | --- | --- | --- | 6 | **1.0E-04[c]** | --- | --- | --- | --- |
| Angelrodt Street | South of Plant 7S | 2 | **4.0E-05[c]** | --- | --- | 1 | 7.5E-07 | --- | --- | 0.6 | 4.6E-07 | --- | --- | --- | --- | --- | --- | 2 | **3.7E-05[c]** | --- | --- | --- | --- |

[a] Radiological COPCs were identified as COCs when a dose and/or CR exceed applicable target criteria (dose = 25 mrem/year; CR = 1E-05). "Radiological COCs" include: Ac-227, Pa-231, Pb-210, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, and U-238. Metal COPCs were identified as COCs when a CR and/or HI exceed 1.0E-05 and/or 1.0, respectively. Metal COCs are identified in parentheses below the associated risk.

"---" = No dose or risk evaluation was performed because either the exposure pathway is incomplete or not applicalbe for the property/receptor scenario.

**Bold font** indicates that the CR is greater than the target value of 1.0E-05. **Bold font with gray shading** indicates that the dose or CR is greater than the 25 mrem/year benchmark or USEPA's highest target value of 1.0E-04, respectively.

[b] Maximum total radiological dose and/or cancer risk estimated over a 1,000-year evaluation period is predominantly driven by external radiation exposures to Ra-226 at time = 0 years.

[c] Maximum total radiological dose and/or cancer risk estimated over a 1,000-year evaluation period is predominantly driven by external radiation exposures to Th-230 in-growth in 1,000 years.

[d] Maximum total radiological dose and/or cancer risk estimated over a 1,000-year evaluation period is predominantly driven by external radiation exposures to Th-232 in-growth in 1,000 years.

## Table 6-3. Summary of Metals Risk Characterization Results for Sewer Sediment by Sampling Location: Sewer Maintenance Worker

| Sewer Sediment Sample Station ID | Description | Total Pathway CR [a] | Total Pathway HI [a] |
|---|---|---|---|
| McKinley Bridge (DT-11) - SLD123488 | Manhole MH-1 Just South of McKinley Bridge | 1.1E-07 | 6.7E-04 |
| Plant 1 - SLD123489 | Manhole Along Salisbury Street | 1.6E-07 | 1.7E-03 |
| Plant 1 - SLD123490 | Surface Drain North of Bldg. 3 | 3.5E-07 | 2.2E-03 |
| Plant 1 - SLD123492 | Surface Drain MH-56 | 1.4E-07 | 8.7E-04 |
| Plant 1 - SLD123493 | Surface Drain MH-55 | 1.9E-07 | 1.2E-03 |
| Plant 1 - SLD123494 | Manhole MH-58 | 1.2E-07 | 7.2E-04 |
| Plant 1 - SLD123495 | Surface Drain Approx. 30 feet from the Southwest corner of Bldg. G | 7.4E-08 | 4.6E-04 |
| Plant 1 - SLD123496 | Surface Drain in the Center of Bldgs. B, C, 10, F, and G | 4.7E-07 | 2.9E-03 |
| Plant 1 - SLD123498 | Surface Drain MH-66 | 7.7E-08 | 4.8E-04 |
| Plant 2 - SLD123740 | Surface Drain MH-51 West of Former 50-Series Bldgs. | 5.2E-08 | 3.3E-04 |
| Plant 2 - SLD123743 | Manhole MH-37 | 4.7E-08 | 2.9E-04 |
| Plant 2 - SLD123744 | Manhole MH-39 South of Plant Along Destrehan Street | 5.8E-08 | 3.6E-04 |
| Plant 6 - SLD123748 | Plant 2/Surface Drain MH-30 East of Plant Along DT-9 (Terminal Railroad) | 7.2E-08 | 4.5E-04 |
| Plant 2 - SLD123749 | Surface Drain North of Bldg 502 | 3.6E-08 | 2.2E-04 |
| Plant 2 - SLD123750 | Curb Drain Outside of Plant Along North Second Street | 7.7E-08 | 4.8E-04 |

[a] Total CR and HI values presented for each location represent the sum of CR and HI values determined for ingestion and dermal exposures to sediment by the sewer maintenance worker.
CR = Cancer risk
EPC = Exposure point concentration represented by individual sample result.
HI = Hazard index

## Table 6-4. Summary of Risk Characterization Results for Soil Adjacent to Sewer Lines: Sewer Utility Worker

| Sewer Borehole Location [a] | Description Relative to Sediment Locations | Radiological Dose/CR | | Metals CR/HI [b] | |
|---|---|---|---|---|---|
| | | Total Maximum Dose (mrem/yr) | Total Maximum CR | Total Location CR | Total Location HI |
| Plant 1 - SLD124540 | Approximately 30 ft east and downstream of surface drain location SLD123495. | 1 | 5.5E-07 | 5.4E-07 | 9.5E-02 |
| Plant 1 - SLD124546 | Located outside of northwest plant boundary along Salisbury St.; downstream of surface drain location SLD123492 (MH-56). | --- | --- | 2.5E-07 | 3.9E-02 |
| Plant 1 - SLD124548 | Located adjacent to surface drain SLD123491 (MH-59), northwest of Bldg. 10. | --- | --- | 6.2E-10 | 6.1E-01 |
| Plant 1 - SLD124554 | Located approx. 60 ft to the east and downstream of surface drain SLD123491 (MH-59); just northeast of Bldg. 10. | --- | --- | 1.0E-11 | 1.0E-02 |
| Plant 1 - SLD125521 | Located approx. 30 ft to the north and downstream of surface drain MH-46 (not sampled), and upstream (south) of surface drain SLD123491 (MH-59). | --- | --- | 1.0E-11 | 1.0E-02 |
| Plant 6 - HTZ88929, HTZ88930 | Sewer Excavation at northwest corner of property | 15 | **1.1E-05** [e] | --- | --- |
| Plant 7N/BNSF (DT-12) - SLD124586 | Located outside of northeast corner of Plant 7N, adjacent to BNSF RR (DT-12). | --- | --- | 6.1E-12 | 6.1E-03 |
| Plant 7N/BNSF Railroad (DT-12) [c] | Sewer Line Excavation | **259** [e] | **1.9E-04** [e] | --- | --- |
| DT-2 (St. Louis City Property) [d] | Sewer Line beneath Levee | **31** [e] | **2.3E-05** | --- | --- |

[a] Borehole location selected based on exceedances of industrial screening levels. EPCs are based on the maximum detection at each borehole.
[b] In addition to CR and HI calculations for arsenic and cadmium, lead is identified as a sewer soil COC based on exceedances of the 800-mg/kg industrial screening level at three Plant 1 locations [SLD124540 (6 to 9 ft), SLD124560 (14 to 14.5 ft), and SLD124570 (8 to 8.5 ft)], one Plant 2 location [SLD124576 (3.5 to 4 ft)], and one Plant 6W location [SLD127572 (6 to 6.5 ft)].
[c] Samples SLD93275, SLD93276, SLD93277
[d] Samples SLD120945, SLD120946, SLD120947, SLD120948
[e] Maximum total radiological dose and/or cancer risk estimated over a 1,000-year evaluation period is predominantly driven by external radiation exposures to Th-230 in-growth in 1,000 years.
CR = Cancer risk
HI = Hazard index
Bold indicates dose, carcinogenic risk or noncarcinogenic HQ/HI exceeding the target levels of 25 mrem/yr, 1E-05 or 1.0, respectively.Bold font with gray shading indicates that the dose or CR is greater than 25 mrem/yr benchmark or USEPA's upper target CR of 1.0E-04, respectively.
"---" = Radiological SOR < 1.0; no metals analyses performed.

# 7.0 SUMMARY AND CONCLUSIONS

This section summarizes the results and conclusions of the RI and answers the following questions:

- What is the nature and extent of MED/AEC contamination associated with inaccessible soil areas, buildings and structures, and sewers at the SLDS (Section 7.1)?
- What areas exceed screening levels (Section 7.1)?
- What areas would pose unacceptable risk to human health and the environment if they become inaccessible (Section 7.2)?
- What are the potential data limitations and recommendations (Section 7.3.1)?

In addition to the above, and consistent with USEPA guidance, the potential RAOs are presented in Section 7.3.2.

## 7.1 NATURE AND EXTENT OF CONTAMINATION

Information obtained from the RI has been used to evaluate the nature and extent of contamination associated with inaccessible soil areas, buildings and structures, and sewers at the SLDS. The following RI field activities were conducted between May 2009 and August 2010 to evaluate the nature and extent of contamination:

- subsurface soil sampling of inaccessible soil beneath or immediately adjacent to buildings and other permanent structures (including the levee, roads, and RRs).
- GWSs,
- building and structural radiological surveys,
- sediment sampling of manholes and surface grates, and
- subsurface soil sampling adjacent to sewer lines.

A brief summary of the nature and extent of contamination for the inaccessible soil areas, buildings and structures, and sewers is presented in Sections 7.1.1 through 7.1.3.

### 7.1.1 Inaccessible Soil Areas

The following paragraphs summarize the nature and extent of contamination in inaccessible soil areas beneath or adjacent to (1) buildings and other permanent structures, (2) the levee, (3) RRs, and (4) roadways.

#### *7.1.1.1 Inaccessible Soil Areas Associated with Buildings and Other Permanent Structures*

Radiological PCOCs were detected above the screening level in inaccessible soil areas beneath or adjacent to buildings and other permanent structures at three Mallinckrodt Plant areas:

- Plant 1: 45 of 279 samples used to evaluate the inaccessible soils at Plant 1 exceeded the radiological screening level. The elevated samples were located in the following areas: three areas adjacent to the Building K excavation, four areas associated with Building 8, a small area beneath Building 25, an area beneath Building 26, a small area north of the Southeast Containment Pad, a small area south of the loading dock south of Building X, and two areas beneath Building X.

- Plant 2: 7 of 166 samples used to evaluate the inaccessible soils at Plant 2 exceeded the radiological screening level. The elevated samples were located in the following areas: an area at Building 508, one area at the northwest end of the 50-series building excavation, a small area south of the 50-series building excavation (north of Building 510), and an area in the southeast corner of Plant 2.
- Plant 6: 4 of 63 samples used to evaluate the inaccessible soils at Plant 6 exceeded the radiological screening level. The elevated samples were located in an area in the southwest corner adjacent to Destrehan Street.

In addition, radiological PCOCs were detected above the screening level in inaccessible soil areas beneath or adjacent to buildings and other permanent structures at three SLDS VPs:

- Gunther Salt (DT-4) North: 71 of 254 samples used to evaluate the inaccessible soils at DT-4 exceeded the radiological screening level. The elevated samples were located in the following areas: areas within and adjacent to the Administration/Warehouse Building, sidewalk along Buchanan Street, salt dome area, an area adjacent to the northeast corner of the Southern Storage Building, and an area beneath the southwest portion of the Southern Storage Building.
- Heintz Steel (DT-6): 15 of 136 samples used to evaluate the inaccessible soils at DT-6 exceeded the radiological screening level. The elevated samples were located in the following areas: beneath the Storage Building and on the western edge of the Storage Building along Hall Street.
- PSC Metals, Inc. (DT-8): 3 of 297 samples used to evaluate the inaccessible soils at DT-8 exceeded the radiological screening level. The elevated samples were located in the following areas: an area of the RR tracks in North Tract 3, an area of the RR tracks in North Tract 4, and an area in the southeast corner of the warehouse located in the South Tract.

Arsenic was detected above the screening level in inaccessible soil areas in the uranium-ore processing area beneath or adjacent to buildings and other permanent structures at three locations on the north and south sides of the Office Building on Thomas and Proetz Lumber Company (DT-10).

#### *7.1.1.2 Inaccessible Soil Areas Associated with the Levee*

Radiological PCOCs were detected above the screening level in four samples collected from one area in the southern portion and one area in the central portion of the St. Louis Riverfront Levee at DT-2. The radiological contamination was found at depths less than 8 ft. A total of 433 samples were used to evaluate the inaccessible soils beneath and adjacent to the levee at St. Louis City Property (DT-2), Terminal RR (DT-9) Levee, and the MSD Lift Station (DT-15).

#### *7.1.1.3 Inaccessible Soil Areas Associated with Railroads*

Radiological PCOCs exceeding screening levels were found at the following RR VPs:

- Norfolk Southern RR VP (DT-3): 6 of 351 samples used to evaluate the inaccessible soils at DT-3 exceeded the radiological screening level. The elevated samples were located in one area east of Plant 3 between Mallinckrodt and Destrehan Streets and one area east of Plant 10 and south of Destrehan Street.

- Terminal RR Association VP (DT-9): 17 of 668 samples used to evaluate the inaccessible soils at the DT-9 main line and rail yard exceeded the radiological screening level. The elevated samples were located in three areas on the main line between the McKinley Bridge and Destrehan Street and three areas in the rail yard (two on the northern RR track and one on the RR track traversing southwest to northeast).
- Terminal RR Soil Spoils Area: 5 of 56 samples used to evaluate the inaccessible soils at Terminal RR Soil Spoils Area exceeded the radiological screening level. The elevated samples were located in a small area at the southern end of the Norfolk Southern RR spur in the northern portion of the property and two isolated areas along the Terminal RR Tracks.
- BNSF RR VP (DT-12): 33 of 480 samples used to evaluate the inaccessible soils at DT-12 exceeded the radiological screening level. The elevated samples were located in one area located north of the McKinley Bridge east of DT-9 and a large area on the west side of the tracks extending from just north of Destrehan Street south to Dock Street.

Two metal PCOCs were detected above screening levels in inaccessible soil areas in the uranium-ore processing area beneath or adjacent to RR tracks at:

- Terminal RR (DT-9) Main Line: Cadmium at one location west of Plant 6.
- BSNF RR (DT-12): Arsenic at several sampling locations east of Plant 7 between Destrehan and Angelrodt Streets.

#### *7.1.1.4 Inaccessible Soil Areas Associated with Roadways*

Roads located outside of the Mallinckrodt Plant areas were not radiologically contaminated. Radiological PCOCs were detected above the screening level along roads within or adjacent to the Mallinckrodt Plant area at the following locations:

- Hall Street: 19 of 255 samples used to evaluate the inaccessible soils at Hall Street exceeded the radiological screening level. The elevated samples were located in two small areas at the property boundaries of Plant 6 and DT-6.
- North Second Street: 1 of 81 samples used to evaluate the inaccessible soils at North Second Street exceeded the radiological screening level. The elevated sample was located west of Building L at Plant 1.
- Mallinckrodt Street: 3 of 70 samples used to evaluate the inaccessible soils at Mallinckrodt Street exceeded the radiological screening level. The elevated samples were located in three small isolated areas located north of Plant 2 Buildings 509, 507, and 502.
- Destrehan Street: 2 of 248 samples used to evaluate the inaccessible soils at Destrehan Street exceeded the radiological screening level. The elevated samples were located in two isolated areas located between North Broadway and Hall Street.
- Angelrodt Street: 1 of 106 samples used to evaluate the inaccessible soils at Angelrodt Street exceeded the radiological screening level. The elevated sample was located south of Plant 7S.

### 7.1.2 Buildings and Structures

Exterior surface activity measurements above the screening level were detected at isolated areas on 3 of the 58 buildings and numerous structures surveyed. The results of the radiological scoping surveys conducted for the RI determined that the following areas exceed the RI screening level:

- Plant 1: a small area, less than 1 $m^2$, on the south exterior wall of Building 25 just above ground level. Over 1,800 measurements were obtained during the scoping surveys at Plant 1.
- Thomas and Proetz Lumber (DT-10): copper flashing above several sliding doors and the glass panels of four skylights of the Wood Storage Building. Over 360 measurements were obtained during the scoping surveys at DT-10.
- Cotto-Waxo (DT-14): A small area on a metal beam at roof level of the L-shaped Building. Over 100 measurements were obtained during the scoping surveys at DT-14.

The radiological scoping survey results indicated that interior building surfaces at the SLDS did not exceed the radiological screening level for industrial use.

### 7.1.3 Sewers

With respect to contamination associated with the sewers, sewer sediment did not indicate radiological contamination exceeding the screening level; however, metals were found to exceed the screening levels at 14 sediment sampling locations. Radiological and metal PCOCs exceeding screening levels were found in soil borings located adjacent to the sewers.

#### *7.1.3.1 Sewer Sediment*

No radiological PCOCs exceeded the screening levels in the 26 sediment samples collected on-site during the RI from manholes and surface grates. Two metals (arsenic and cadmium) were detected at levels above the RI screening levels in 14 sewer sediment samples at the following four areas:

- Plant 1: Various Sewer Sediment Locations (arsenic and cadmium),
- Plant 2: Various Sewer Sediment Locations (arsenic),
- Plant 6: Sewer Sediment Locations (arsenic), and
- Illinois DOT and Missouri DOT (DT-11): Sewer Sediment Location (arsenic).

#### *7.1.3.2 Soil Adjacent to Sewers*

A total of 105 soil samples were collected from 28 soil borings located adjacent to sewers; in addition, 9 excavation sidewall samples were collected adjacent to sewer lines as part of remediation activities conducted under the 1998 ROD. Elevated concentrations of the radiological PCOCs were observed in 13 of these 114 soil samples. The following areas exceeded the radiological screening level and were retained for further evaluation in the BRA:

- Radiological contamination was identified in subsurface soil adjacent to a segment of a 15-in sewer line located east of former Building G at Plant 1. This sewer line is located approximately 9 to 10 ft bgs, and the contamination extends from approximately 7 to 12 ft bgs. Arsenic, cadmium, and lead are present at concentrations which exceed their corresponding screening levels at this boring location.
- Radiological contamination was identified in two subsurface soil samples collected adjacent to the sewer line that extends from Plant 6WH to beneath Hall Street. No metals data was available for these samples.

- Radiological contamination was identified in soil surrounding a 30-in sewer line that runs west to east along the south side of Destrehan Street to the Mississippi River. The accessible portions of this sewer line have been or will be remediated under the 1998 ROD. However, the portions extending under the BNSF RR (DT-12) and the levee (DT-2) are not accessible and are evaluated in the BRA.

The above results are limited to those soil borings adjacent to sewer lines that had radiological PCOCs above the screening level. In addition to the above locations, arsenic, cadmium, and/or lead exceeded screening levels at nine soil borings located adjacent to sewer lines, but were not commingled with radiological PCOCs at these locations:

- arsenic, cadmium, and/or lead at six Plant 1 borings,
- lead in one Plant 2 boring,
- lead in one Plant 6WH boring, and
- cadmium in one Plant 7N/BNSF RR (DT-12) boring.

## 7.2 SUMMARY OF FINDINGS OF THE BASELINE RISK ASSESSMENT

As summarized in Section 6.0, a BRA was performed to estimate current and potential future dose and risks to human and ecological receptors that could result from exposures to radiological and metals COPCs in inaccessible soil and sewer sediment that were not addressed in the 1998 ROD (USACE 1998a). The BRA consists primarily of two components: a quantitative HHRA and a qualitative ecological assessment, the summaries and findings of which are discussed in Sections 7.2.1 and 7.2.2, respectively.

### 7.2.1 Human Health Risk Assessment

The HHRA quantitatively evaluated dose and risk for properties and ISOU media with concentrations of PCOCs exceeding screening levels. In the HHRA, radiological COPCs were evaluated for dose and carcinogenic risks and metal COPCs were evaluated for CRs and non-carcinogenic HIs. Radiological COPCs were pre-determined to be those radionuclides associated with former MED/AEC operations: Ac-227, Pa-231, Ra-226, Ra-228, Th-230, Th-232, U-235, and U-238. For inaccessible soil and sediment, $SOR_N$ values greater than or equal to a value of 1.0 were used as the basis for determining the ISOU media and areas to be evaluated for radiological dose and risk. Specific building surfaces were identified for evaluation in the HHRA from exceedances of a surface screening level (3,900 dpm/100 $cm^2$) by gross alpha measurements, the results of which are summarized above in Section 7.1.2. Metal COPCs in inaccessible soil, sewer sediment, and soil adjacent to sewer lines were identified in Section 4.0 as those metals that exceed corresponding risk-based industrial screening levels. Inaccessible soil metal COPCs were identified for only properties located within the uranium ore processing area. Depending on the property, metal COPCs in inaccessible soil included arsenic and/or cadmium. Depending on location, metal COPCs in soil adjacent to sewer lines included arsenic, cadmium, and/or lead.

Complete exposure pathways were determined for receptors in the ISOU CSM (Figure 5-1), which assumes current configurations (i.e., buildings, structures, and ground cover in place). The current and expected future land use of the SLDS as a heavily industrial/urban area was the basis for identifying six human receptor scenarios for evaluation in the HHRA:

- industrial worker exposed to all inaccessible soil across a property,
- industrial worker exposed to property-wide inaccessible and accessible soil (combined),
- construction workers exposed to inaccessible soil at RR properties and roadways,

- utility workers exposed to inaccessible soil at elevated measurement areas and soil locations adjacent to sewer lines,
- recreational users exposed to inaccessible soil at the St. Louis City Property (DT-2),
- industrial workers exposed to radiologically contaminated soil on exterior building/structural surfaces, and
- sewer maintenance workers exposed to sediment inside of sewer lines.

A two-tiered HHRA process was applied to the evaluations of soil dose and risk at each property. The first conservative step in the process (Tier 1 evaluation) was the assumption that the inaccessible soil would become accessible at some point in the future to the industrial worker at all properties and the recreational user at the St. Louis City Property (DT-2); therefore no cover was assumed. Properties exceeding dose or risk target criteria for inaccessible soil during Tier 1 were retained for the Tier 2 evaluation, which involved evaluation of property-wide industrial worker exposures to combined inaccessible and accessible soil. The recreational user at the St. Louis City Property was retained for Tier 2 regardless of the dose or risk results. The construction worker scenario was evaluated for only inaccessible soil exposures at the RR properties and roadways, independent of the two-tiered evaluation process. Based on the property-wide HHRA results, 13 properties (including 2 plant properties, the St. Louis City Property, 2 industrial/commercial VPs, 3 RRs, and 5 roadways) of the 16 properties evaluated in the HHRA had dose and/or risk that exceeded target criteria and are being retained for further evaluation in the FS, as presented below.

- *Plant Properties (Industrial Worker – Combined Inaccessible and Accessible Soil)*:
  - Plant 1 – Radiological COCs
  - Plant 6 – Radiological COCs
- *Industrial/Commercial VPs (Industrial Worker – Combined Inaccessible and Accessible Soil)*:
  - St. Louis City Property (DT-2) – Radiological COCs
  - Gunther Salt (DT-4) North – Radiological COCs
  - Heintz Steel (DT-6) – Radiological COCs
- *Inaccessible Soil at Railroad VPs (Industrial Worker)*:
  - Norfolk Southern RR (DT-3) – Radiological COCs
  - Terminal RR (DT-9) Main Tracks – Radiological COCs
  - Terminal RR (DT-9) Rail Yard – Radiological COCs
  - Terminal RR Soil Spoils Area – Radiological COCs
  - BNSF RR (DT-12) – Radiological COCs and arsenic
- *Inaccessible Soil at Roadways (Industrial Worker)*:
  - Hall Street (West of Plant 6) – Radiological COCs
  - North Second Street (West of Plant 1) – Radiological COCs
  - Mallinckrodt Street (North of Plant 2) – Radiological COCs
  - Destrehan Street (West of Hall Street) – Radiological COCs
  - Angelrodt Street (South of Plant 7S) – Radiological COCs

In addition to the property-wide evaluations, individual elevated measurement areas of inaccessible soil were evaluated assuming a utility worker would be actively working in the contaminated zone for the entire exposure period. Only 1 elevated measurement area (Plant 1, Building 26) out of the 35 areas evaluated, is being retained for further evaluation in the FS.

None of the 3 buildings/structures evaluated for radiologically contaminated soil on exterior surfaces exceeded dose or risk target criteria; therefore, no buildings/structures are being further evaluated in the FS.

For sewers there were no exceedances of the radiological screening levels and none of the sewer line sediment samples evaluated for metals exceed risk criteria. Therefore, sewer sediment is not being retained for evaluation in the FS. The HHRA evaluated dose and risk for soil adjacent to sewer lines at 10 borehole locations and 3 areas of sewer excavations. The dose and risk estimated for radiological and metal COPCs at all of the borehole locations are below target criteria; however lead concentrations exceed the screening level of 800 mg/kg at 4 of the 10 boreholes evaluated in the HHRA. Additionally, radiological dose and/or risk at all 3 of the sewer excavation areas exceed target criteria. Therefore, lead concentrations at the 4 soil boreholes and radiological contamination at all 3 sewer excavation areas evaluated are being retained for further evaluation in the FS.

In summary, the following locations associated with the sewers are being retained for further evaluation in the FS:

- *Inaccessible Soil Adjacent to Sewer Lines (Sewer Utility Worker)*:
    - Plant 1, Boreholes SLD124540 (Radiological COCs and Lead), SLD124560 (Lead), and SLD124570 (Lead)
    - Plant 2, Borehole SLD124576 – Lead
    - Plant 6, Sewer Line in Northwest Corner of Property, beneath Hall Street – Radiological COCs
    - Plant 6, Borehole SLD127572 – Lead
    - St. Louis City Property (DT-2), Sewer Line beneath the Levee – Radiological COCs
    - Plant 7N/BNSF RR (DT-12), Sewer Line beneath the RR Tracks – Radiological COCs

### 7.2.2 Ecological Risk Assessment

A qualitative ecological assessment was conducted based on the environmental assessment of biota conducted for accessible media in 1993 BRA (DOE 1993) and the findings of a September 10, 2010, site visit that documented the environmental setting, potential receptors, contaminant fate and transport, and exposure pathways per USEPA guidance (1997c). USACE concurs with the findings of the 1993 ecological evaluation that potential impacts to ecological receptors from ISOU media are likely to be insignificant. Given that some remediation at the SLDS has been conducted since 1993, potential impacts to ecological resources from the ISOU contaminated media are likely to be less significant than determined during the 1993 BRA. As a result of the qualitative ecological assessment findings, the ISOU BRA does not include a comprehensive ecological risk assessment.

## 7.3 CONCLUSIONS

The BRA assessed the dose and risk status of each property, based on evaluations of combined accessible soil and ISOU data sets. The information provided in this RI and the BRA forms the basis for identifying and evaluating potential remedial alternatives in the FS to address those areas having COPC concentrations exceeding the CERCLA risk range. Based on the results of the RI and BRA, radiological and metals COCs are retained for further evaluation in the FS. The ISOU media and areas that will be evaluated in the FS are identified in Section 7.2.1

### 7.3.1 Data Limitations and Recommendations for Future Work

It is recommended that the ISOU proceed to the FS phase of the CERCLA process. During the RI, the extent and depth of contaminants were examined. However, some limited additional sampling of sewers, inaccessible soils and buildings may be necessary to support development of alternatives and designs. Additional radiological surveys/sampling may be necessary to fulfill MARSSIM-like requirements for release. Some additional monitoring may be conducted and data reported as part of the ongoing environmental monitoring program for SLDS until remedial actions are completed under the 1998 ROD.

### 7.3.2 Preliminary Remedial Action Objectives

Following completion of the BRA, a FS will be conducted that will focus on those ISOU areas having COPC concentrations exceeding the CERCLA risk range. Generally, as part of the RI/FS process, RAOs are developed to specify the requirements that remedial alternatives must fulfill to protect human health and the environment. Preliminary RAOs have been developed for the ISOU and are presented below. These preliminary RAOs are subject to modifications and refinement as the ISOU progresses through the FS process.

- Prevent exposure to inaccessible soil beneath buildings or other structures contaminated with MED/AEC-related COCs at concentrations that exceed radiological-specific ARARs, result in an excess lifetime cancer risk greater than the acceptable risk range, or dose above 25 mrem/yr.
- Prevent exposure to inaccessible soil adjacent to sewer lines contaminated with MED/AEC-related COCs at concentrations that exceed radiological-specific ARARs, result in an excess lifetime cancer risk greater than the acceptable risk range, or dose above 25 mrem/yr.
- Prevent exposure to inaccessible sewer sediment in sewer lines contaminated with MED/AEC-related COCs at concentrations that exceed chemical-specific ARARs or that result in an excess lifetime cancer risk greater than the acceptable risk range or that result in a HI >1, or exceed the lead RSL.

# 8.0 REFERENCES


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40 *CFR* 192, Subpart A. *Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites.*

40 *CFR* 300.430, Subpart E. *Remedial Investigation/Feasibility Study and Selection of Remedy.*

49 *CFR* 174, Transportation; *Carriage by Rail.*

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# FIGURES

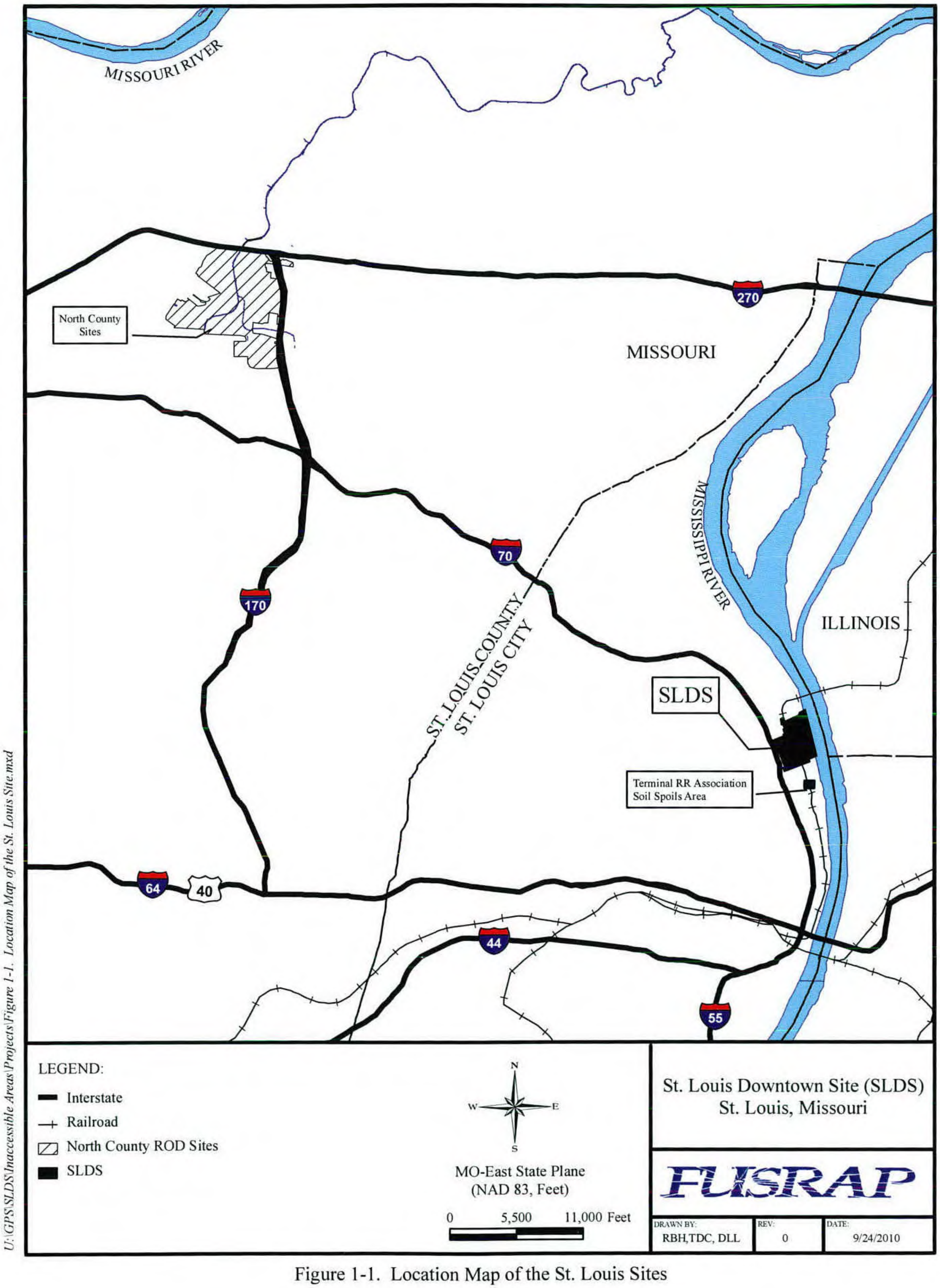


Figure 1-1. Location Map of the St. Louis Sites

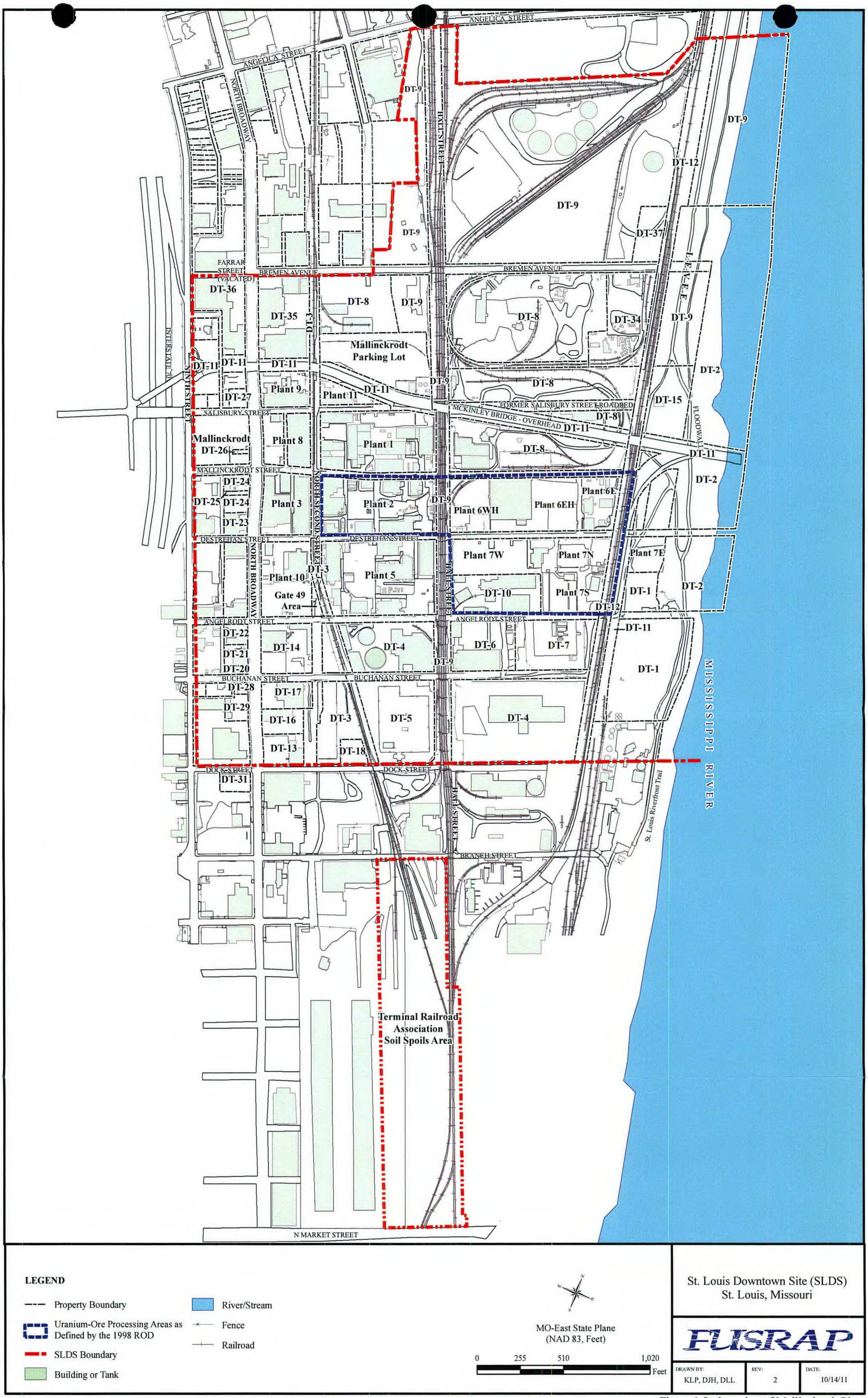


Figure 1-2. Location of Mallinckrodt Plant Areas and Vicinity Properties

U:\GPS\SLDS\Inaccessible Areas\Projects\ISOU RI Report\RevB\Figure 1-2 Location of Mallinckrodt Plant Areas and Vicinity Properties (LARGE LABELS).mxd

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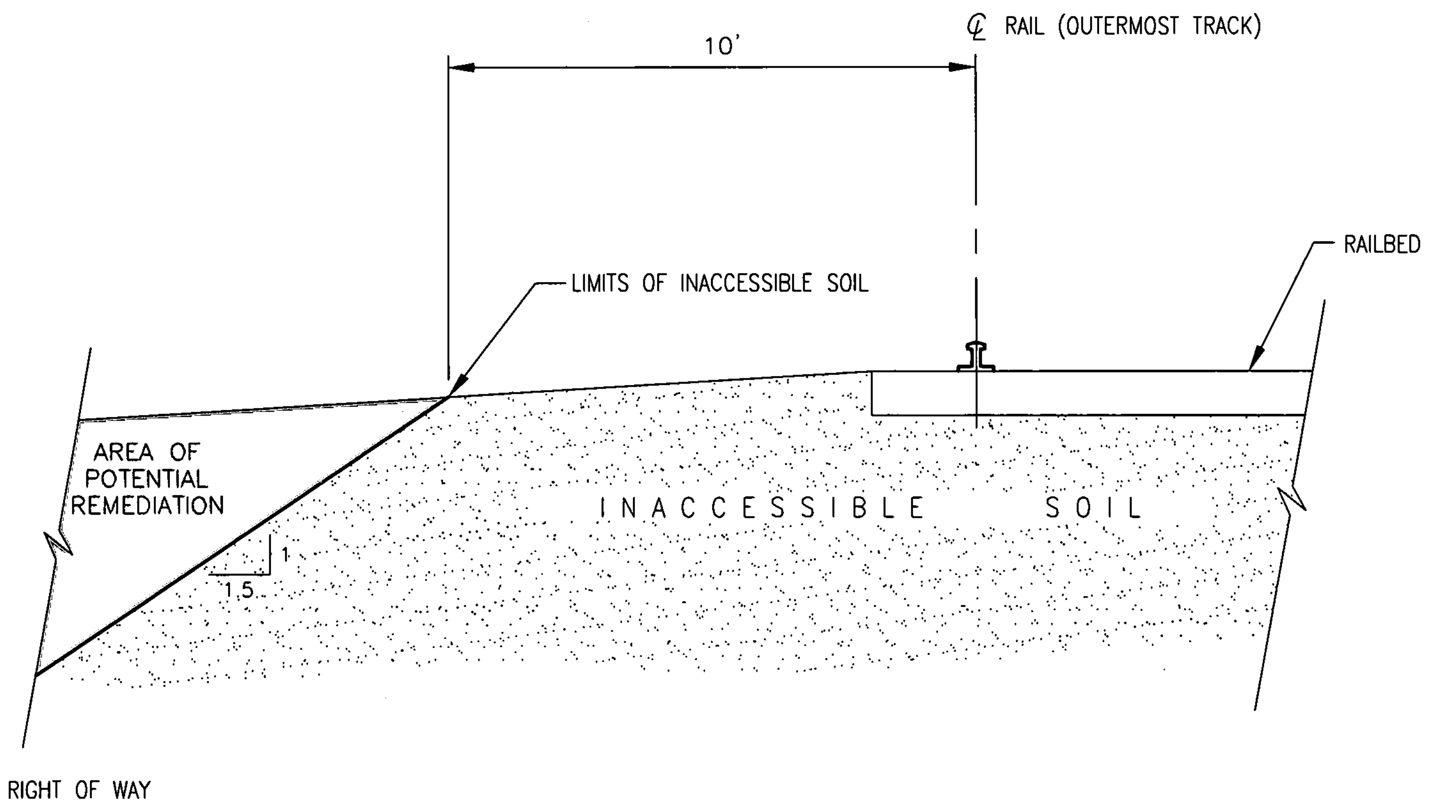


NOTES:

1. SLOPE SHOWN IS APPROXIMATE. ACTUAL SLOPE WILL DEPEND UPON SOIL PROPERTIES OF AREA IN QUESTION AND ACTUAL DEPTH OF CUT. SHORING WITH SHEETPILING MAY ALSO BE NECESSARY.
2. LIMITS OF INACCESSIBLE SOIL ARE TYPICAL ALONG OUTERMOST TRACK.

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St. Louis Downtown Site

St. Louis, Missouri

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| F. Bauer | 09/14/11 |

Figure 2-3. Typical Rail Bed Inaccessible Soil Profile

| Unit Designation | Approximate Thickness (ft) | Description |
|---|---|---|
| Upper Hydrostratigraphic Unit (HU-A) | 0-25 | **FILL**<br>Grayish black (N2) to brownish black (5YR2/1). Dry to slightly moist, generally becoming moist at 5 to 6 ft and saturated at 10 to12 ft. Slight cohesion, variable with depth, moisture content and percentage of fines present. Consistency of relative density is unrepresentative due to large rubble fragments.<br>Rubble is concrete, brick, glass, and coal slag. Percentage of fines as silt or clay increases with depth from 5 to 30%. Some weakly cemented aggregations of soil particles.<br>Adhesion of fines to rubble increases with depth and higher moisture content.<br>Degree of compaction is slight to moderate with frequent large voids. |
| | 0-10 | **Silty CLAY (CH)**<br>Layers are mostly olive gray (5Y2/1) with some olive black (5Y2/1). Predominantly occurs at contact of undisturbed material or at boundary of material with elevated activity.<br>Abundant dark, decomposed organics.<br>Variable percentages of silt and clay composition. |
| | 0-5 | **CLAY (CL)**<br>Layers are light olive gray (5Y5/2) or dark greenish gray (5GY4/1). Slightly moist to moist, moderate cohesion, medium stiff consistency. Tends to have lowest moisture content.<br>Slight to moderate plasticity. |
| | 0-2.5 | **Interbedded CLAY, silty CLAY, SILT and Sandy SILT (CL, ML, SM)**<br>Dark greenish gray (5GY4/1) to light olive gray (5Y6/1). Moist to saturated, dependent on percentage of particle size. Contacts are sharp, with structure normal to sampler axis to less than 15 degrees downdip. Layer thicknesses are variable, random in alternation, with no predictable vertical gradiation or lateral continuity.<br>Some very fine-grained, rounded silica sand as stringers. Silt in dark mafic, biotite flakes.<br>Some decomposed organics. |
| Lower Hydrostratigraphic Unit (HU-B) | 0-10 | **Sandy SILT (ML)**<br>Olive gray (5Y4/1). Moist with zones of higher sand content saturated. Slight to moderate cohesion, moderate compaction. Stiff to very stiff consistency, rapid dilatancy, nonplastic.<br>Sand is well sorted, very fine, and fine-grained rounded quartz particles. |
| | 0-50 | **Silty SAND and SAND (SM, SP, SW)**<br>Olive gray (5Y4/1). Saturated, slight cohesion, becoming noncohesive with decrease of silt particles with depth. Dense, moderate compaction.<br>Moderate to well-graded, mostly fine- and medium-grained with some fine- and coarse-grained particles. Mostly rounded with coarse grains slightly subrounded.<br>Gradual gradation from upper unit, silty sand has abundant dark mafic/biotite flakes.<br>Sand is well-graded, fine gravel to fine sand. Mostly medium-grained, with some fine-grained and few coarse-grained and fine gravel. |
| Limestone Bedrock Unit (HU-C) | Total thickness not penetrated during drilling | **LIMESTONE**<br>Light olive gray (5Y4/1) with interbedded chert nodules. Generally hard to very hard; difficult to scratch with knife. Slightly weathered, moderately fresh with little to no discoloration or staining.<br>Top 5 ft is moderately fractured with 99% of joints normal to the core axis. Joints are open, planar, and smooth. Some are slightly discolored with trace of hematite staining. |

Source: Modified from BNI 1994.

Note: The codes in parentheses following lithologies are the Unified Soil Classification System (USCS) codes.

The codes in parentheses following the colors represent chroma, hue, and value from the Munsell soil color charts.

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St. Louis Downtown Site
St. Louis, Missouri

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Figure 3-1. Generalized Stratigraphic Column for the SLDS

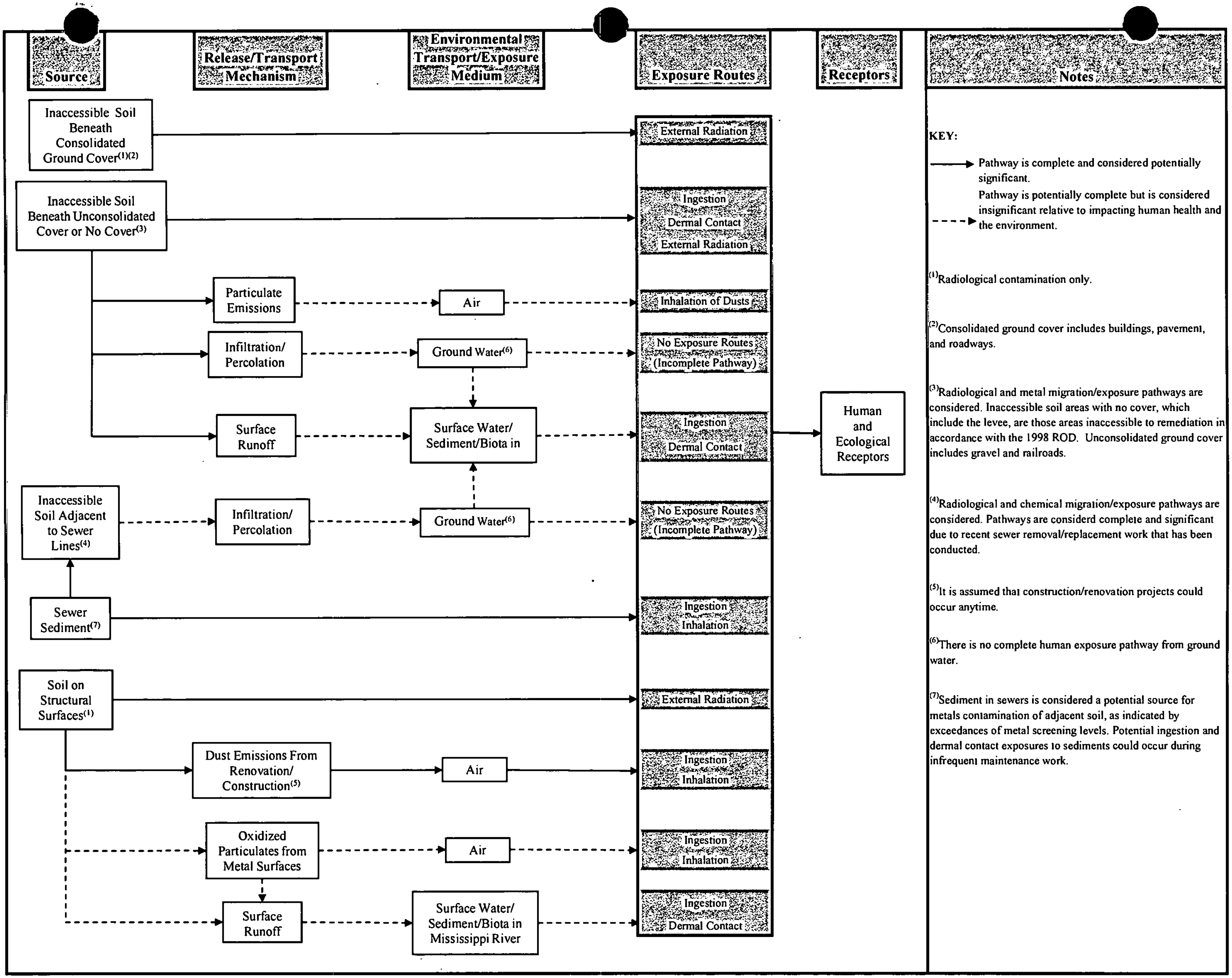


Figure 5-1. Conceptual Site Model for St. Louis Downtown Site, Inaccessible Soil Operable Unit

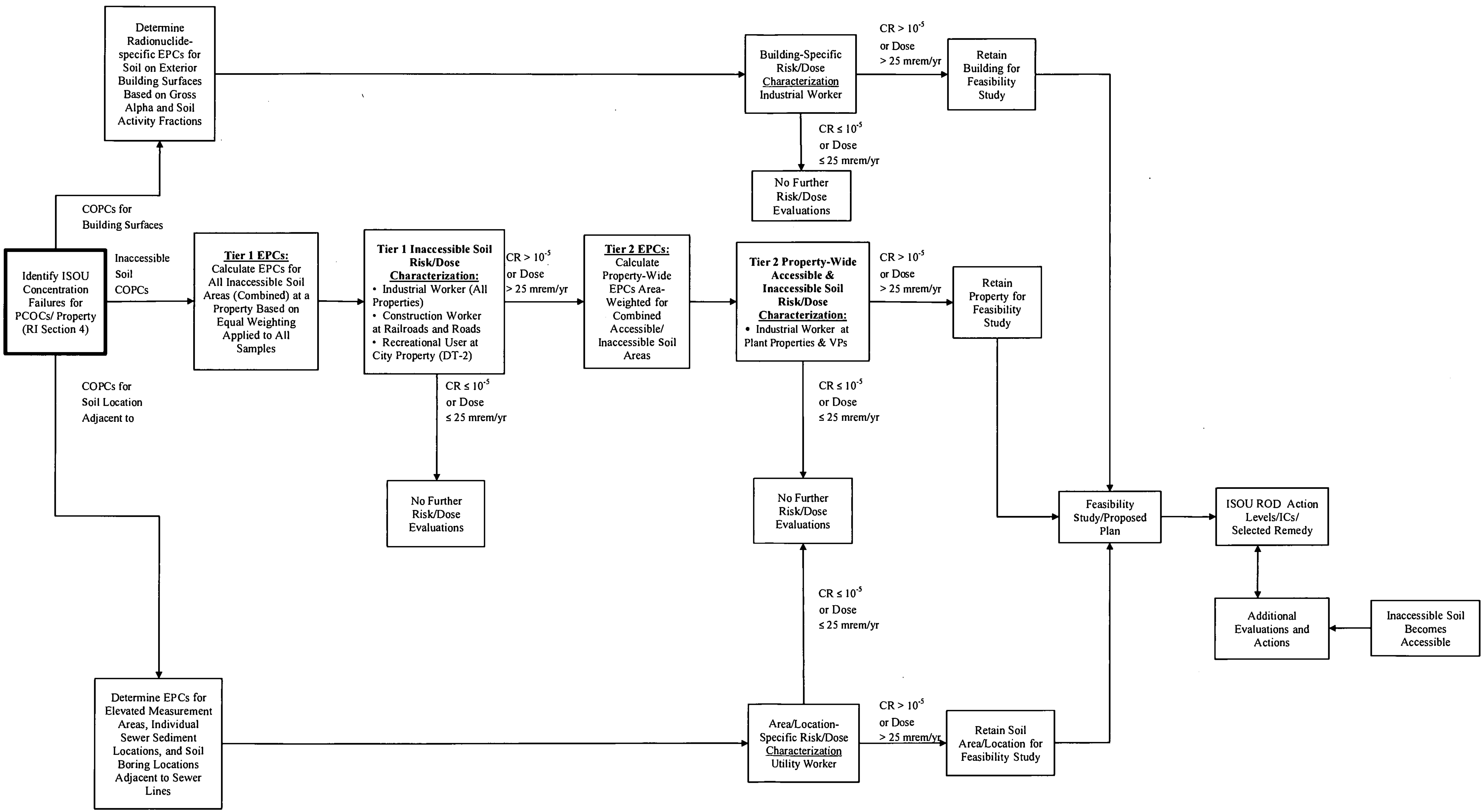


Figure 6-1. ISOU Human Health Risk Assessment Process within CERCLA Framework

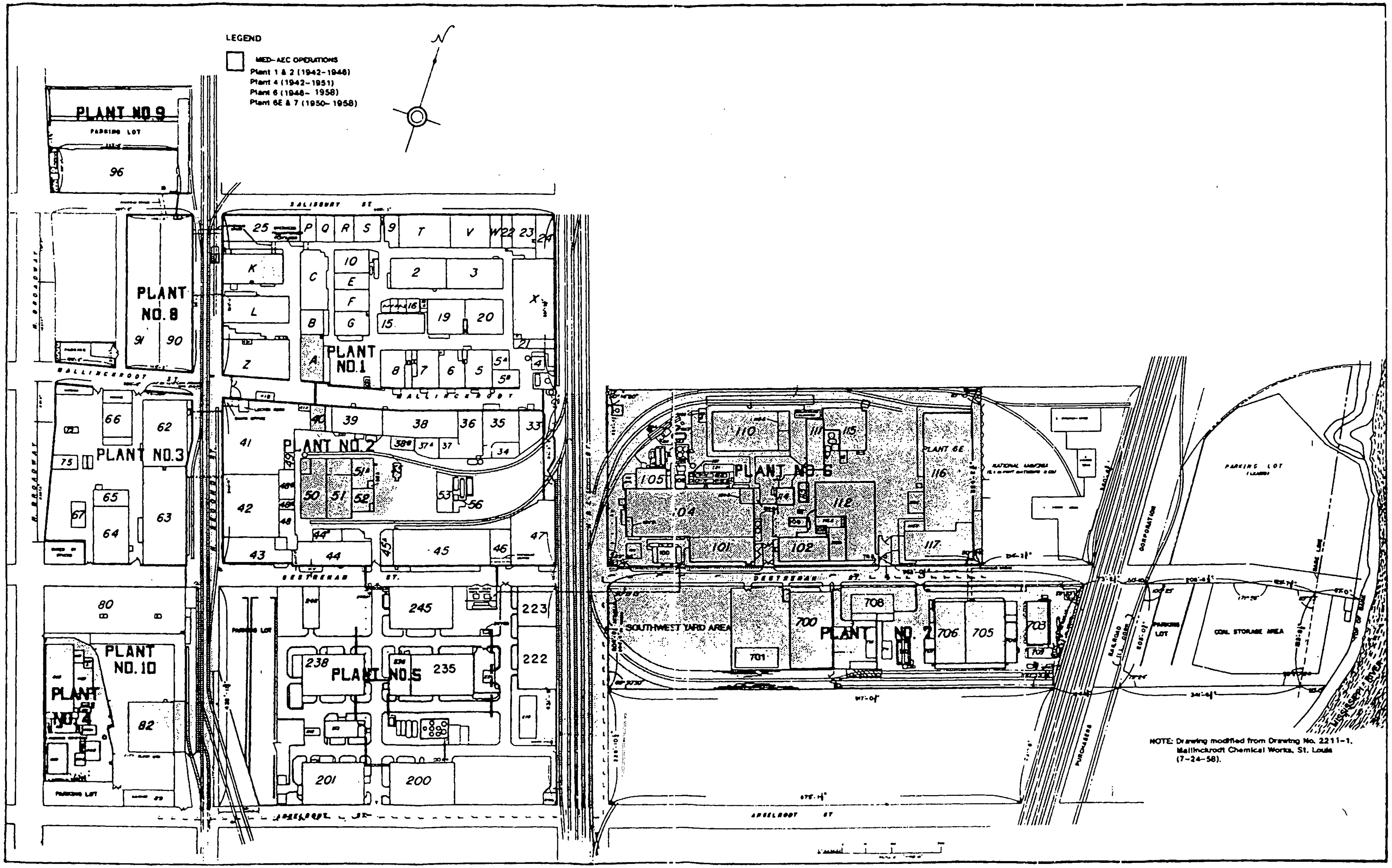


Figure 1-3. Historic Layout (1958) of the MED/AEC and Mallinckrodt Plant Facility

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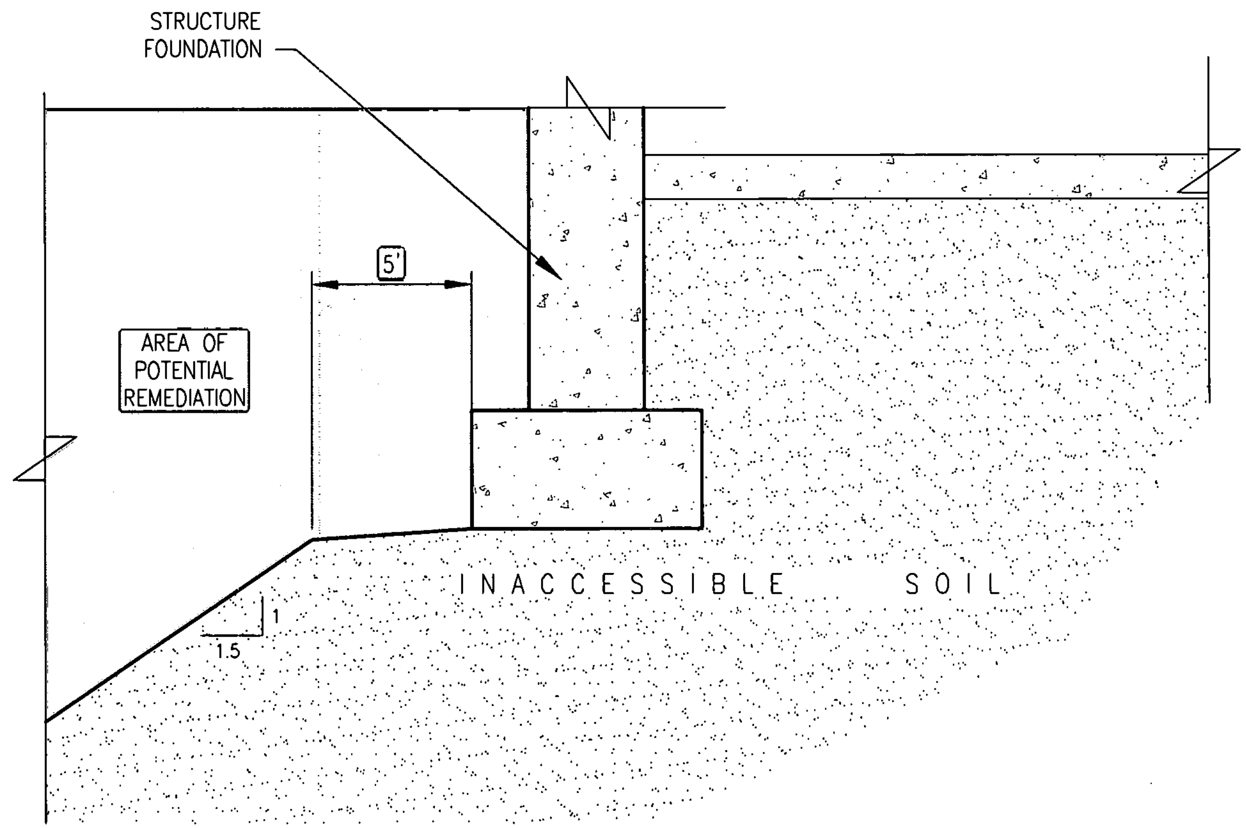


NOTES:

1. SLOPE SHOWN IS APPROXIMATE. ACTUAL SLOPE WILL OEPEND UPON SOIL PROPERTIES OF AREA IN QUESTION AND ACTUAL DEPTH OF CUT. SHORING WITH SHEETPILING MAY ALSO BE NECESSARY.

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St. Louis Downtown Site

St. Louis, Missouri

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Figure 2-1. Typical Structure Foundation Inaccessible Soil Profile

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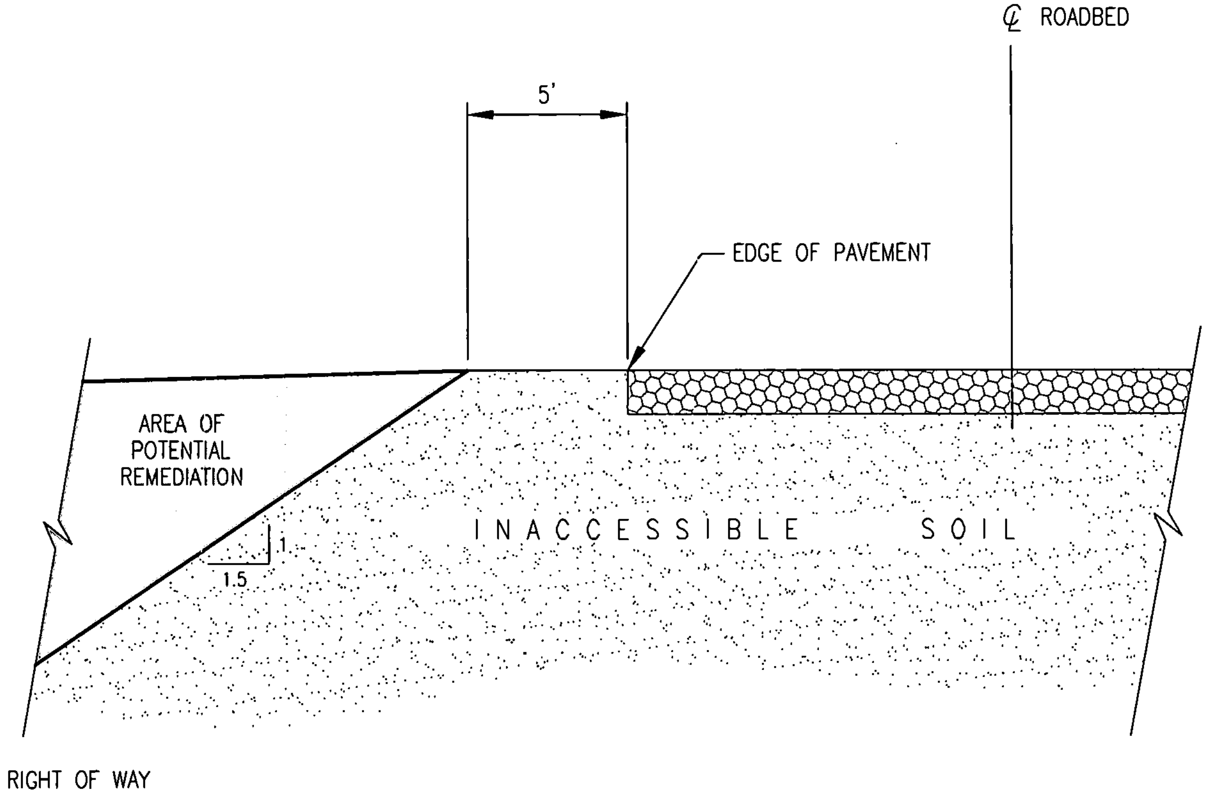


NOTES:

1. SLOPE SHOWN IS APPROXIMATE. ACTUAL SLOPE WILL DEPEND UPON SOIL PROPERTIES OF AREA IN QUESTION AND ACTUAL DEPTH OF CUT. SHORING WITH SHEETPILING MAY ALSO BE NECESSARY.

2. LIMITS OF INACCESSIBLE SOIL ARE SYMMETRICAL ABOUT CENTER LINE OF ROADWAY.

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St. Louis Downtown Site

St. Louis, Missouri

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Figure 2-2. Typical Roadway Inaccessible Soil Profile

# APPENDIX A

## Soil Boring Logs

## (On the CD-ROM on the Back Cover of this Report)

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# APPENDIX B

## Quality Control Summary Report

## (On the CD-ROM on the Back Cover of this Report)

# APPENDIX C

## Figures: RI Sampling Locations for Inaccessible Soil Areas and Buildings and Extent of Contamination for Inaccessible Soil Areas

## LIST OF FIGURES


Plant 1
St. Louis Downtown Site
St. Louis, Missouri

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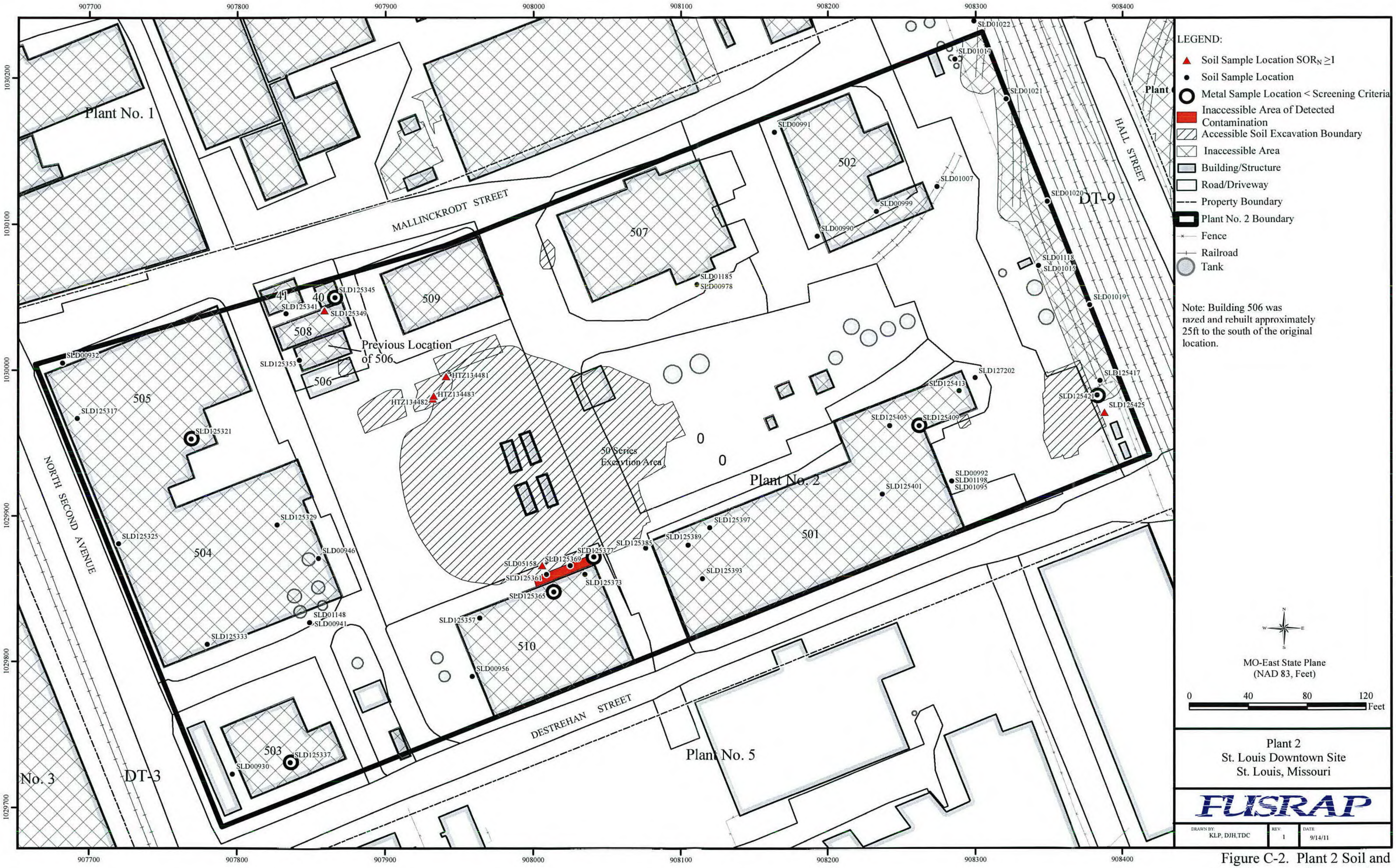
Figure C-1. Plant 1 Soil and Building Sampling Locations




Plant 2
St. Louis Downtown Site
St. Louis, Missouri

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Figure C-2. Plant 2 Soil and Building Sampling Locations

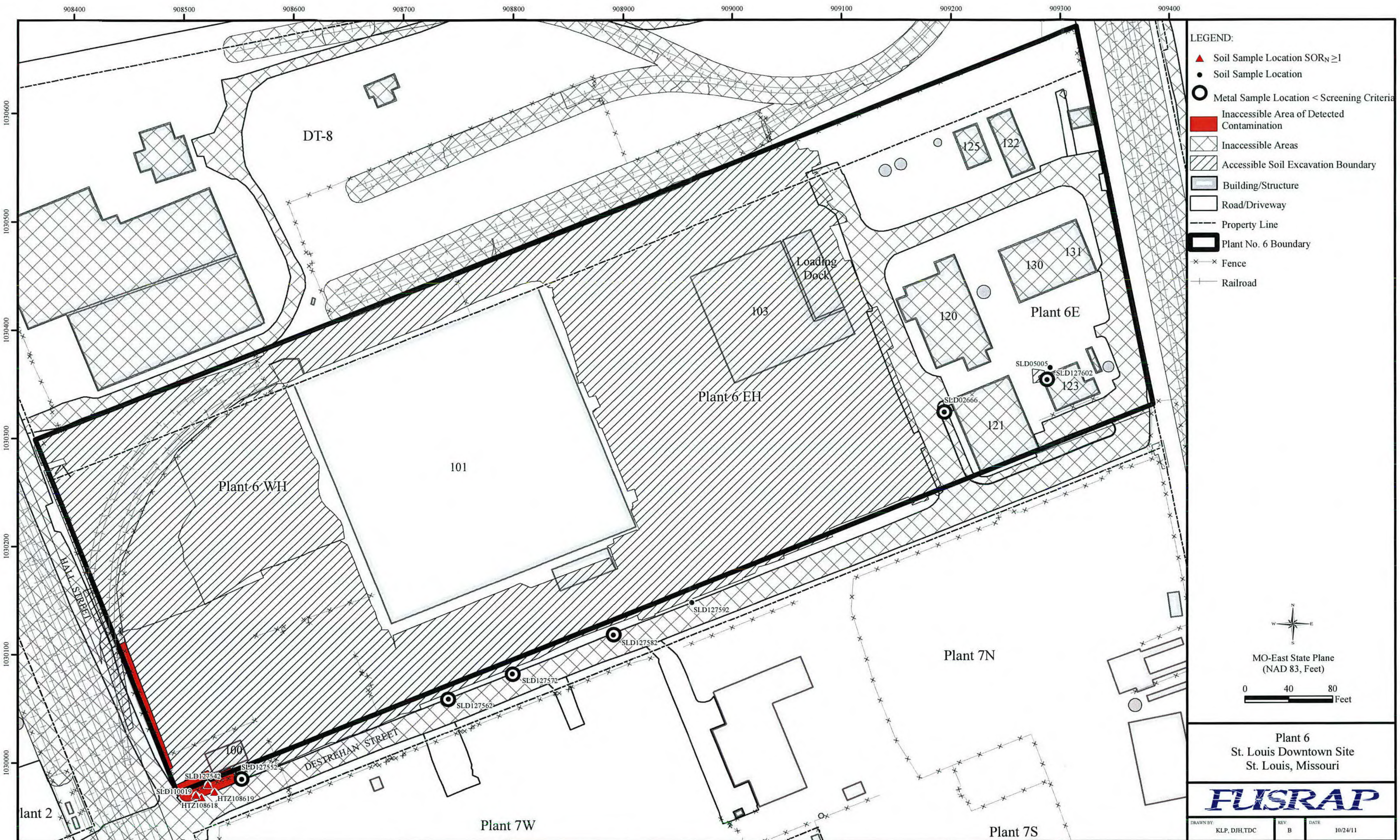



Figure C-3. Plant 6 and 6E Soil and Building Sampling Locations

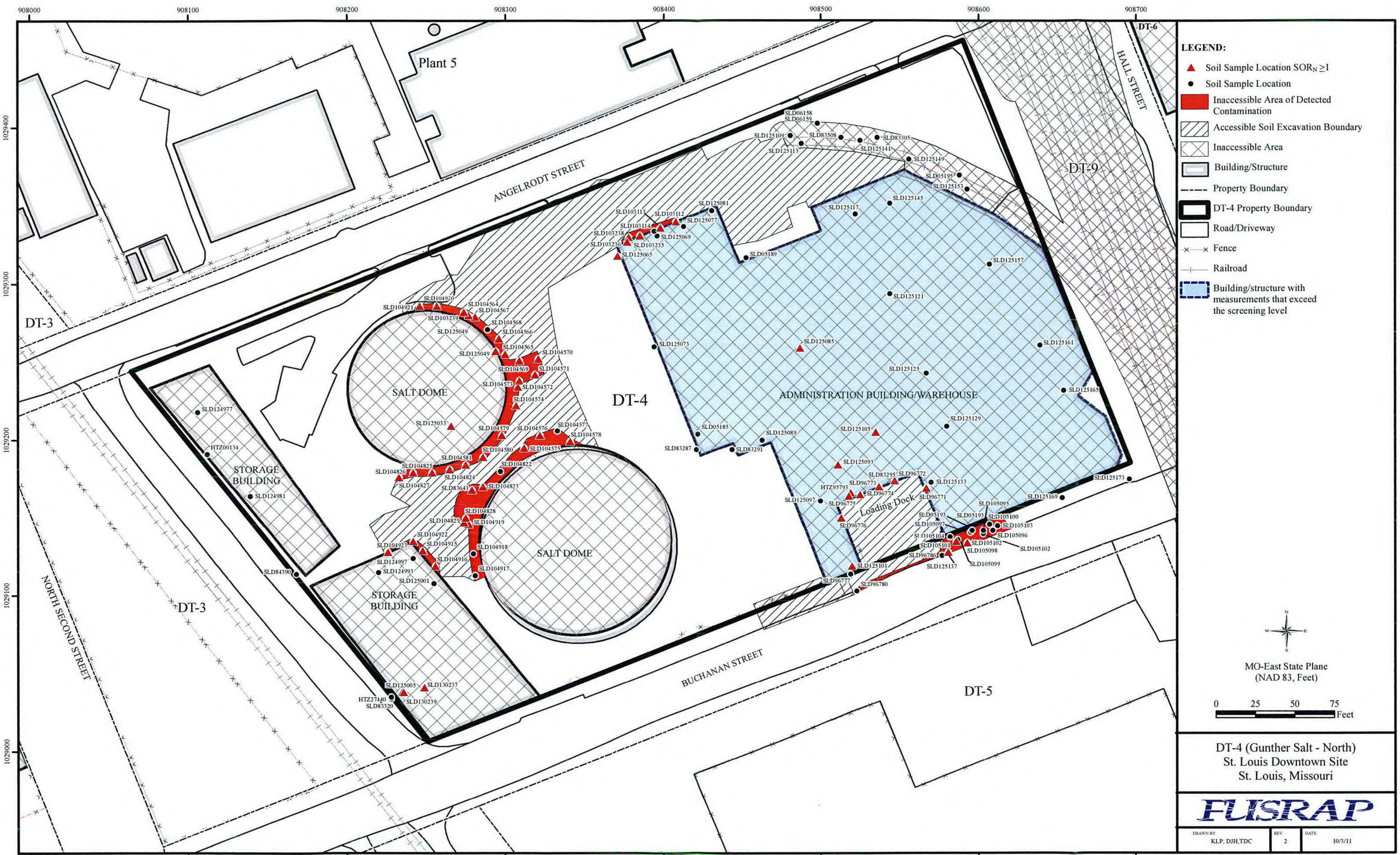



Figure C-7. DT-4 (Gunther Salt North) Soil and Building Sampling Locations

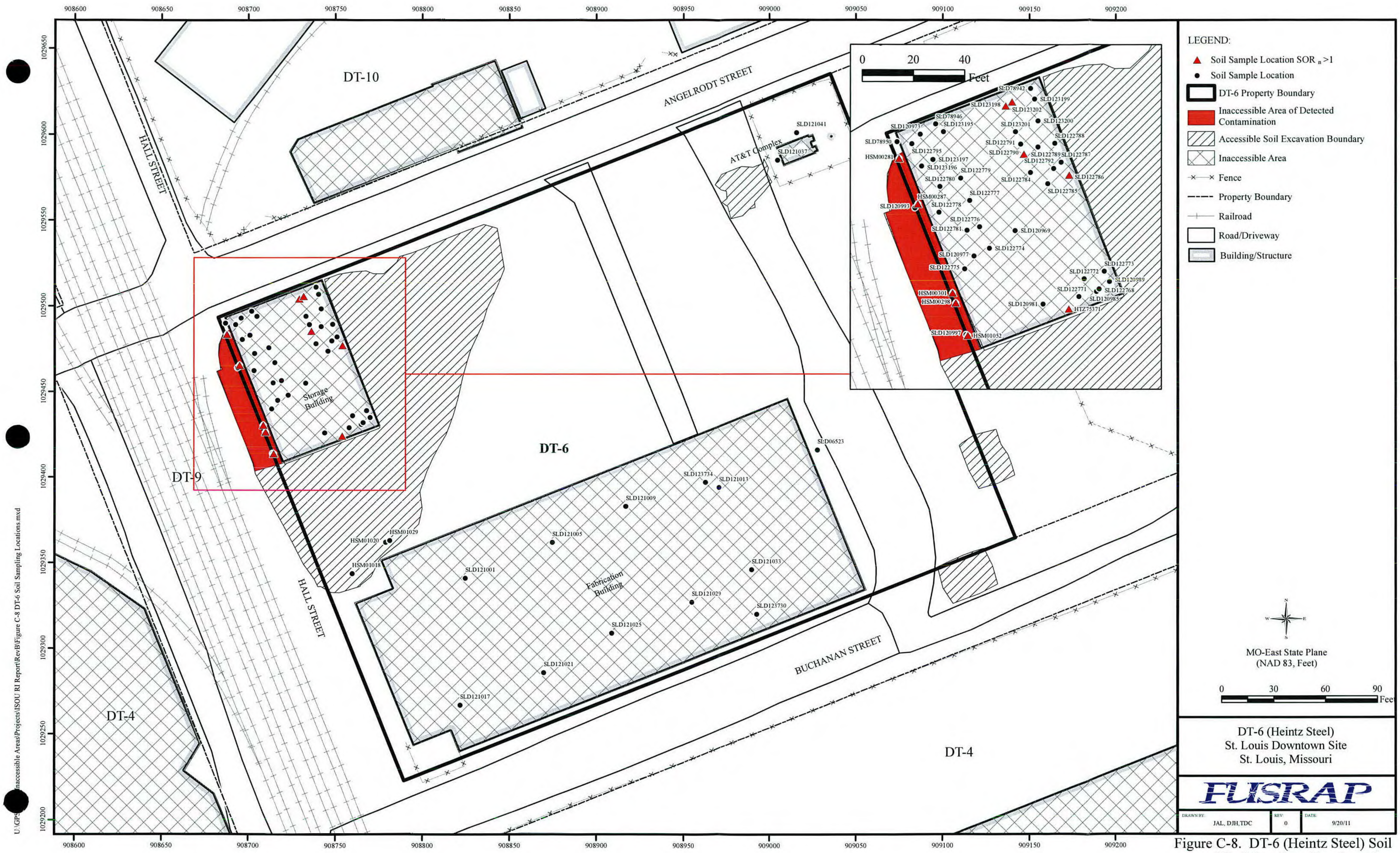



Figure C-8. DT-6 (Heintz Steel) Soil and Building Sampling Locations

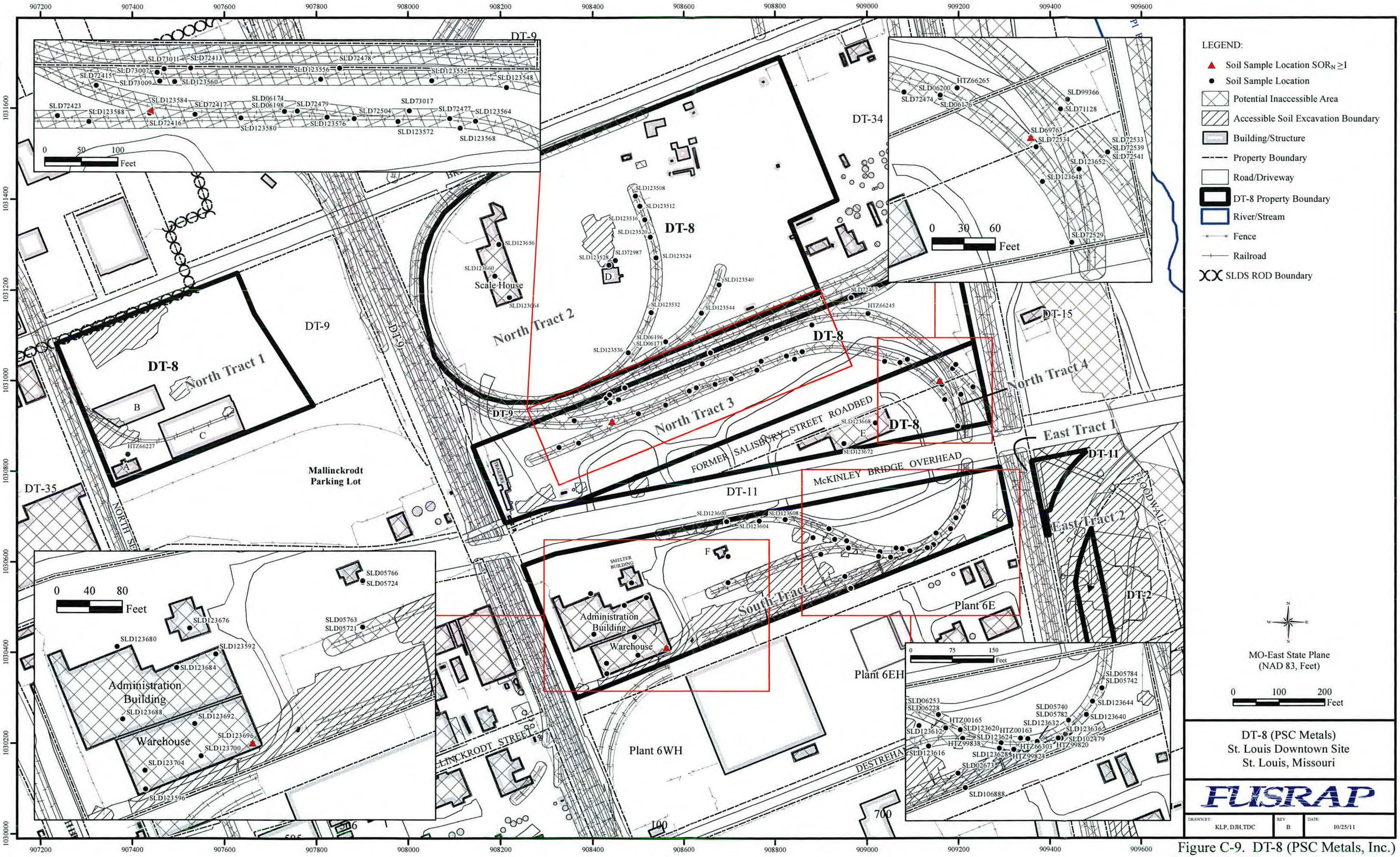



Figure C-9. DT-8 (PSC Metals, Inc.)
Soil and Building Sampling Locations

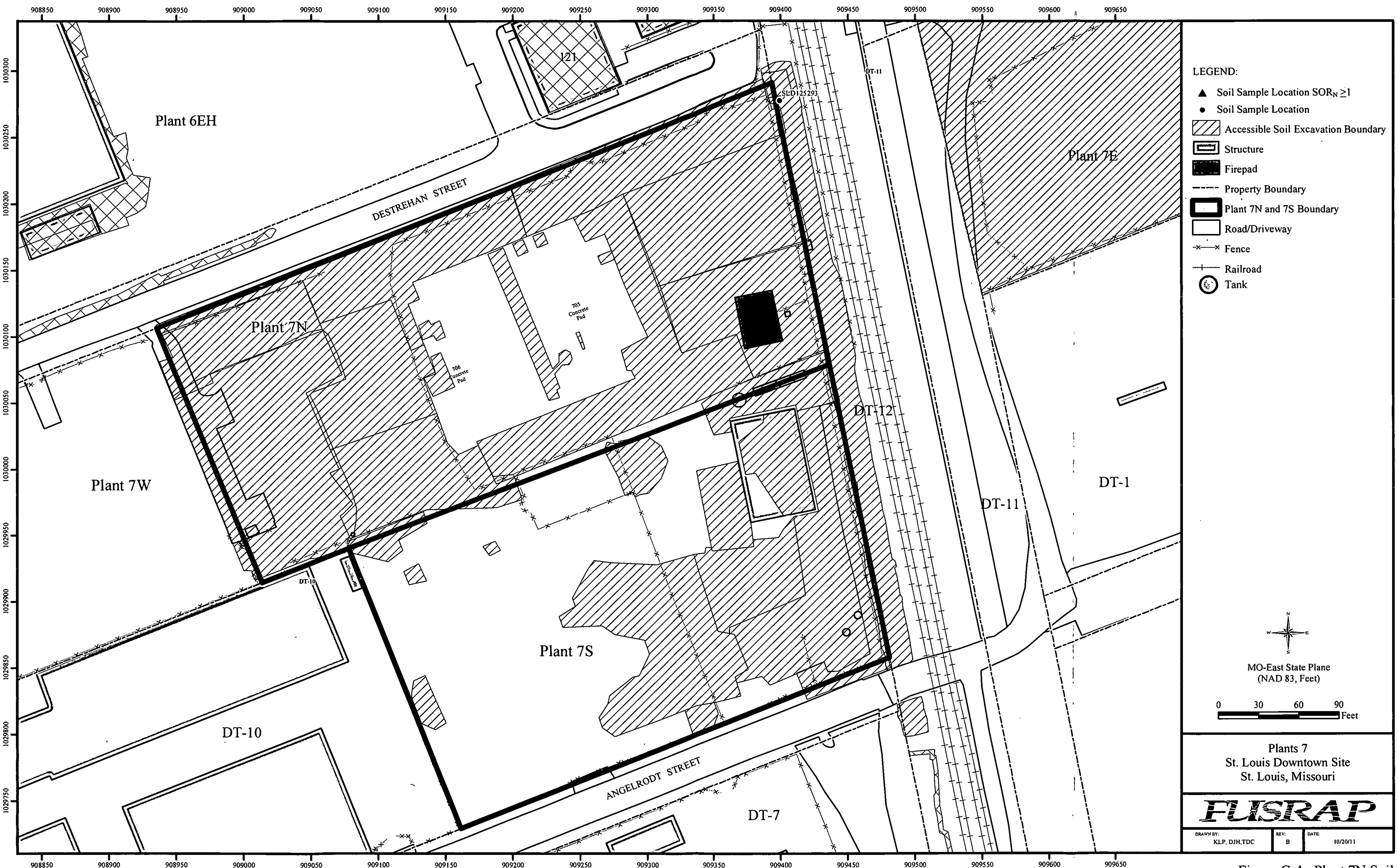



Figure C-4. Plant 7N Soil Sampling Locations

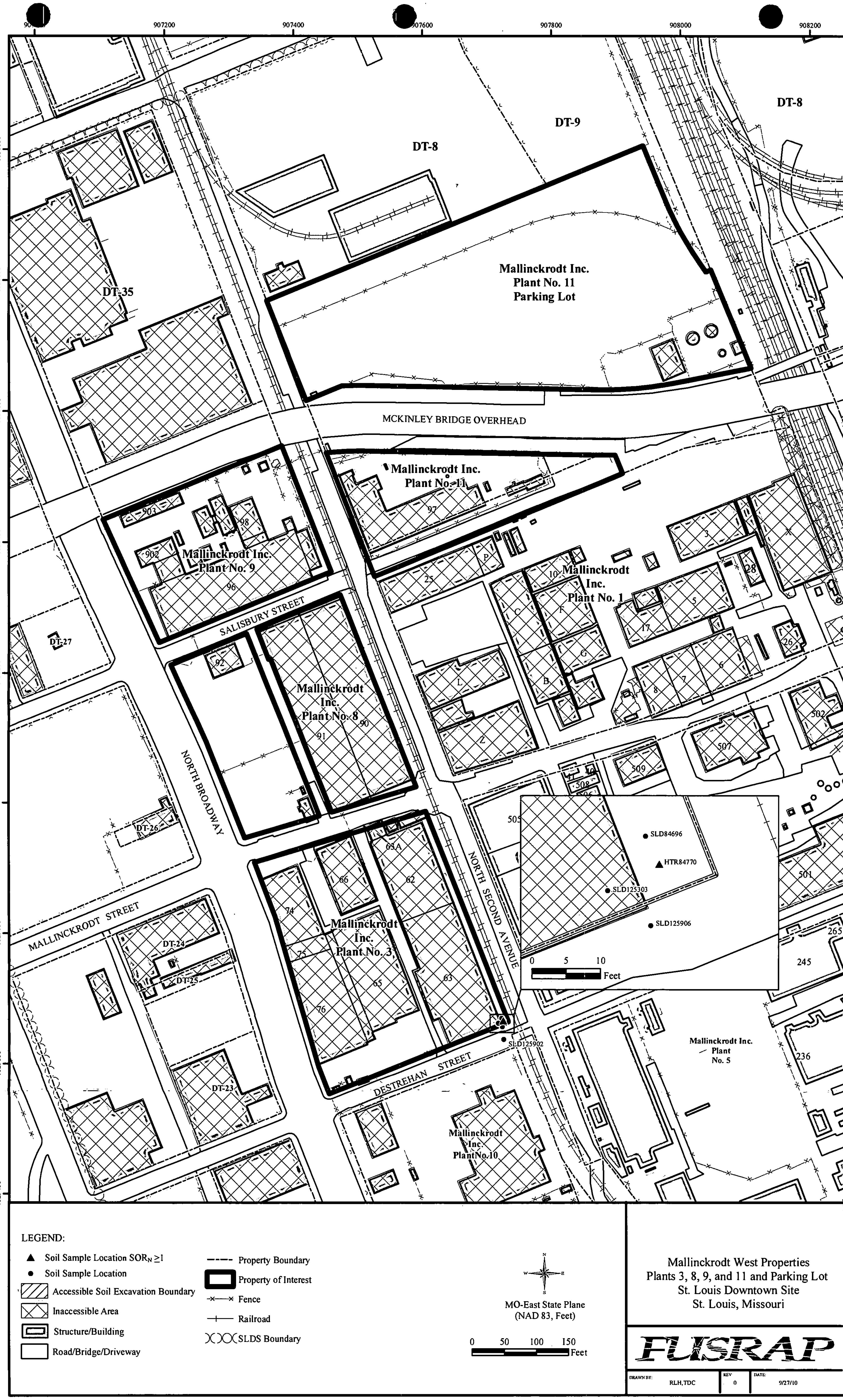



Figure C-5. Mallinckrodt West Properties; Plants 3, 8, 9 and 11
Soil and Building Sampling Locations

U:\GPS\SL ccessible Areas\Projects\ISOU RI Report\RevB\Figure C-6 Gate 49.mxd

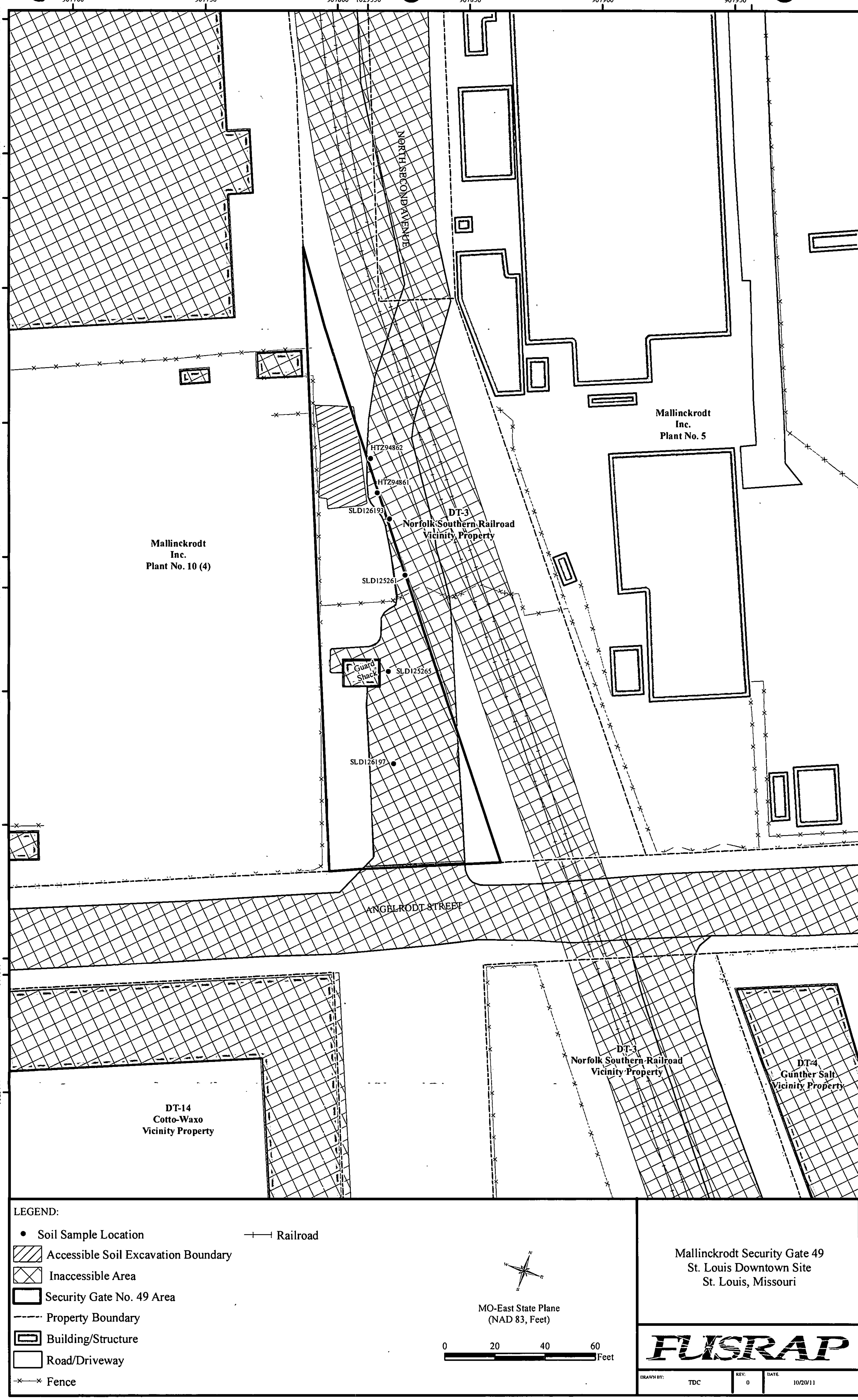



Figure C-6. Mallinckrodt Security Gate 49
Soil Sampling Locations

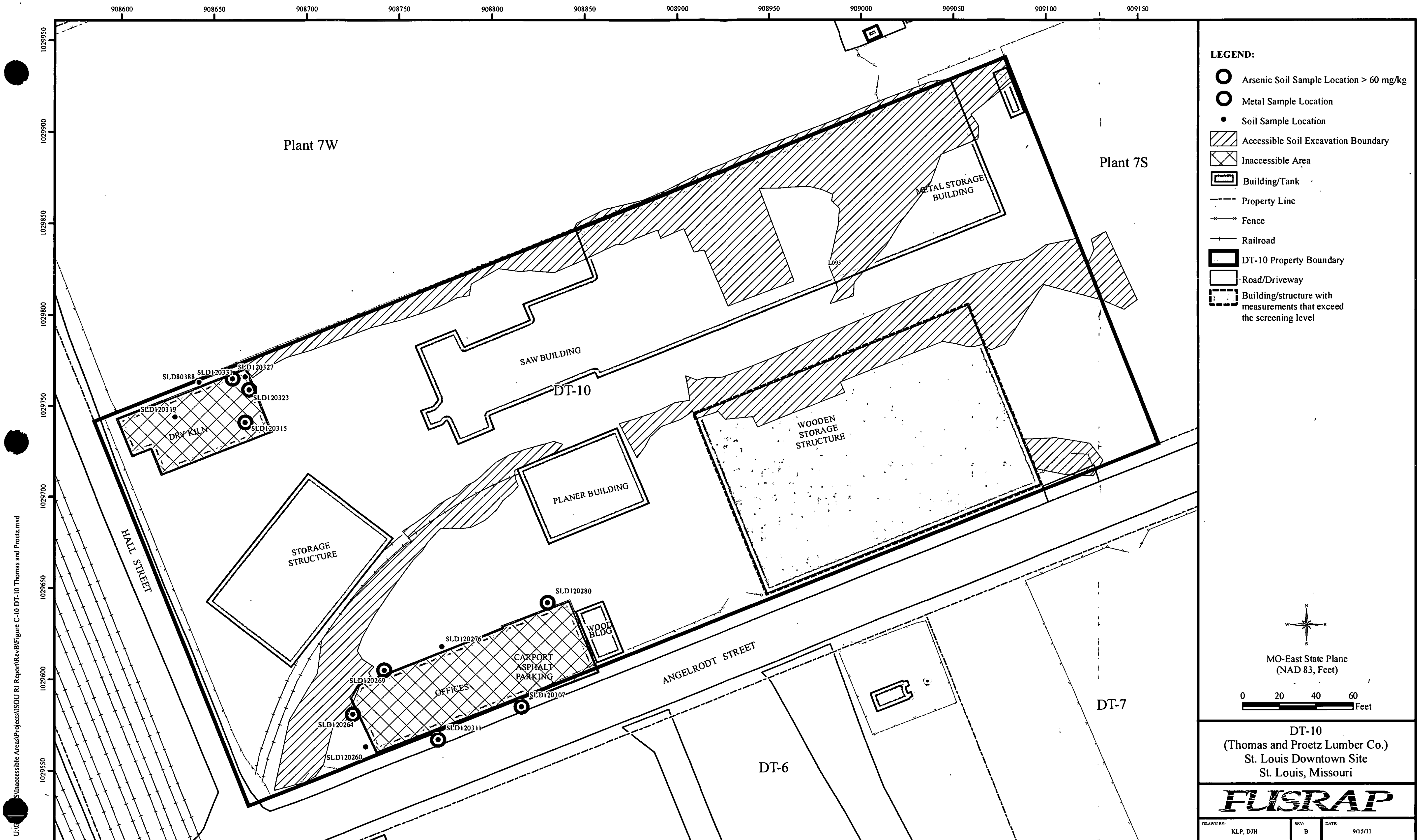



Figure C-10. DT-10 (Thomas and Proetz Lumber Company)
Soil and Building Sampling Locations

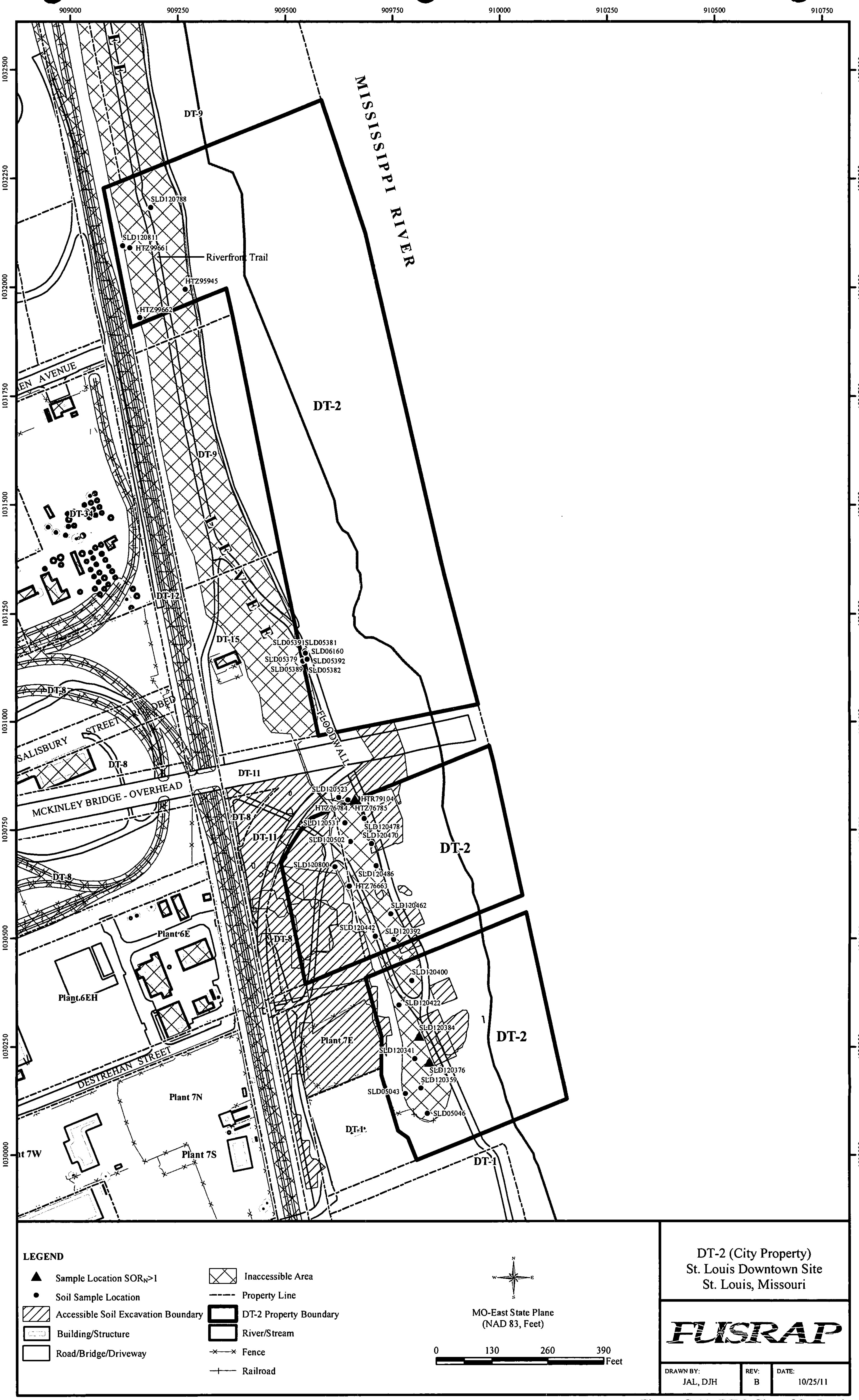
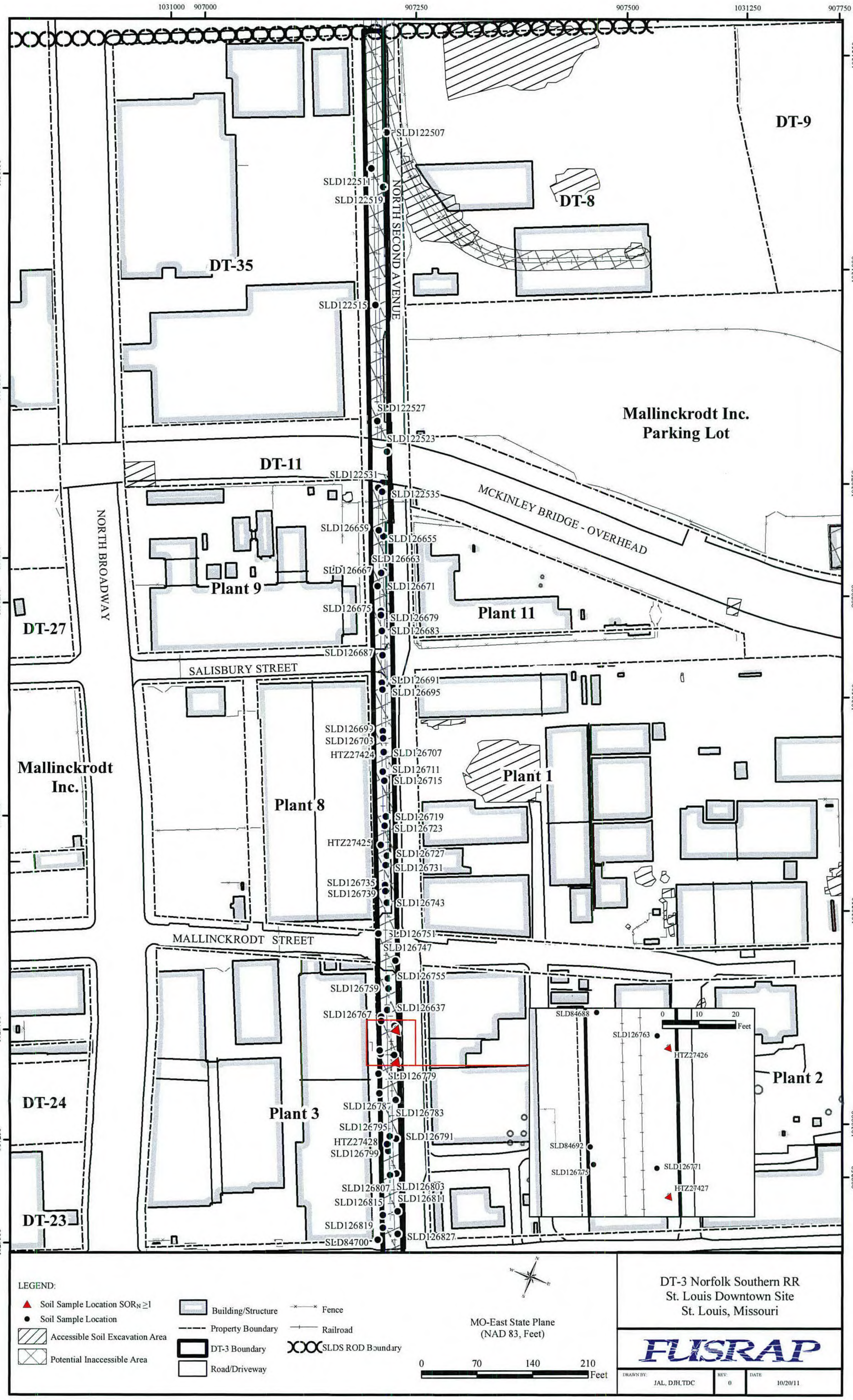



Figure C-11. DT-2 City of St. Louis Soil Sampling Locations


Figure C-12. DT-15 (MSD Lift Station)
Soil Sampling Locations




DT-3 Norfolk Southern RR
St. Louis Downtown Site
St. Louis, Missouri

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Figure C-13. DT-3 Norfolk Southern RR Soil Sampling Locations (North )

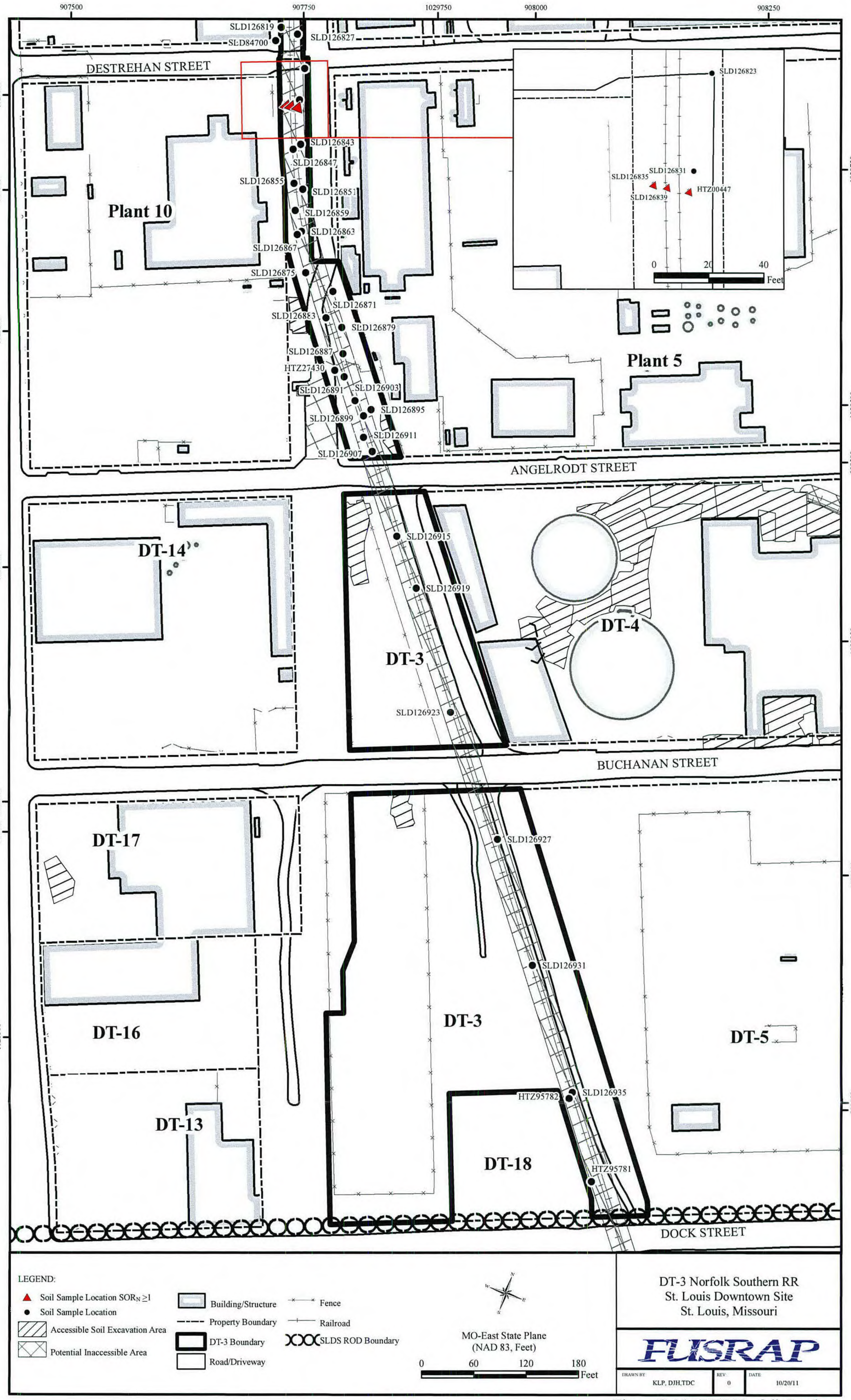


Figure C-14. DT-3 Norfolk Southern RR Soil Sampling Locations (South)

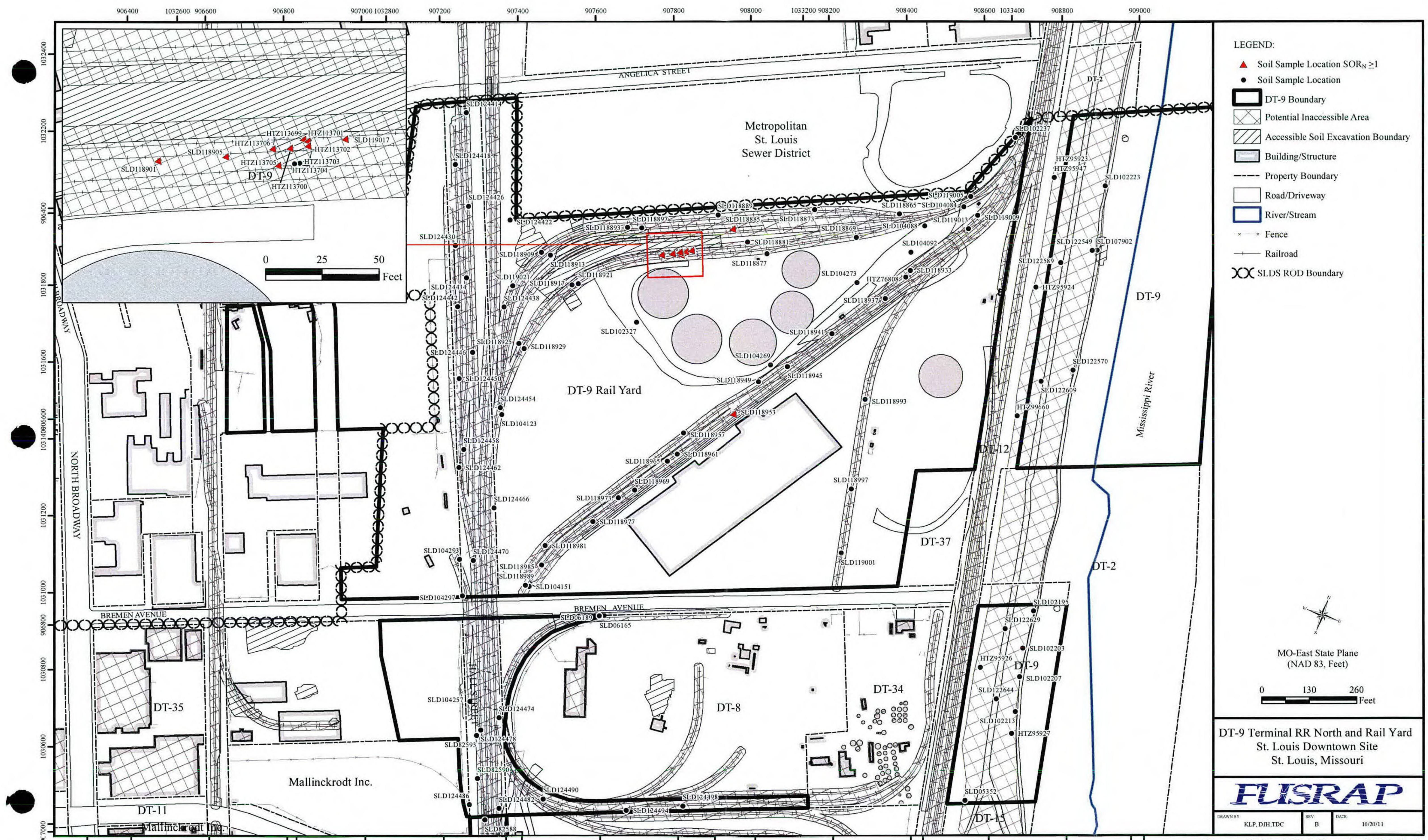


Figure C-15. DT-9 Terminal RR Soil Sampling Locations (North)

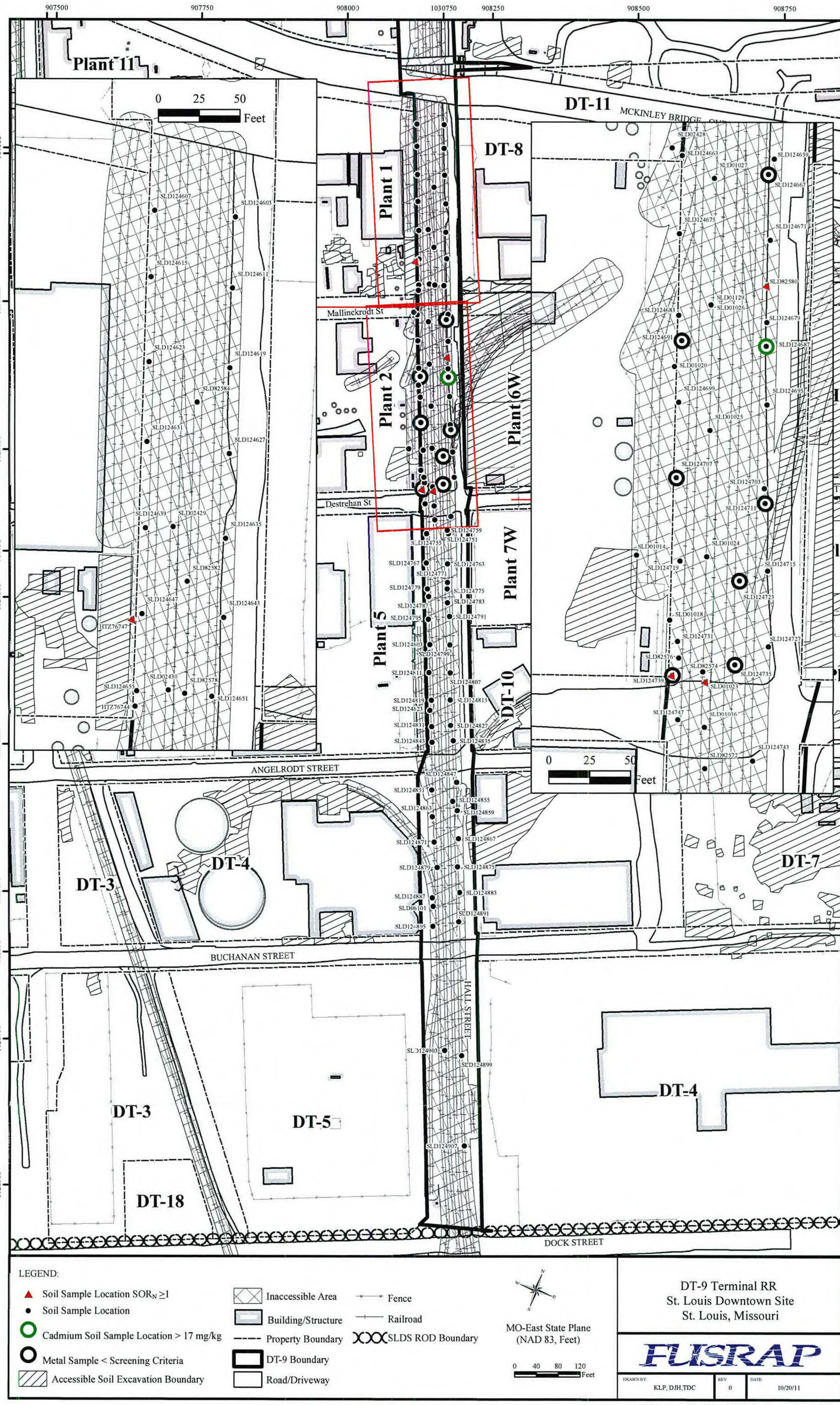


Figure C-16. DT-9 Terminal RR
Soil Sampling Locations (South)

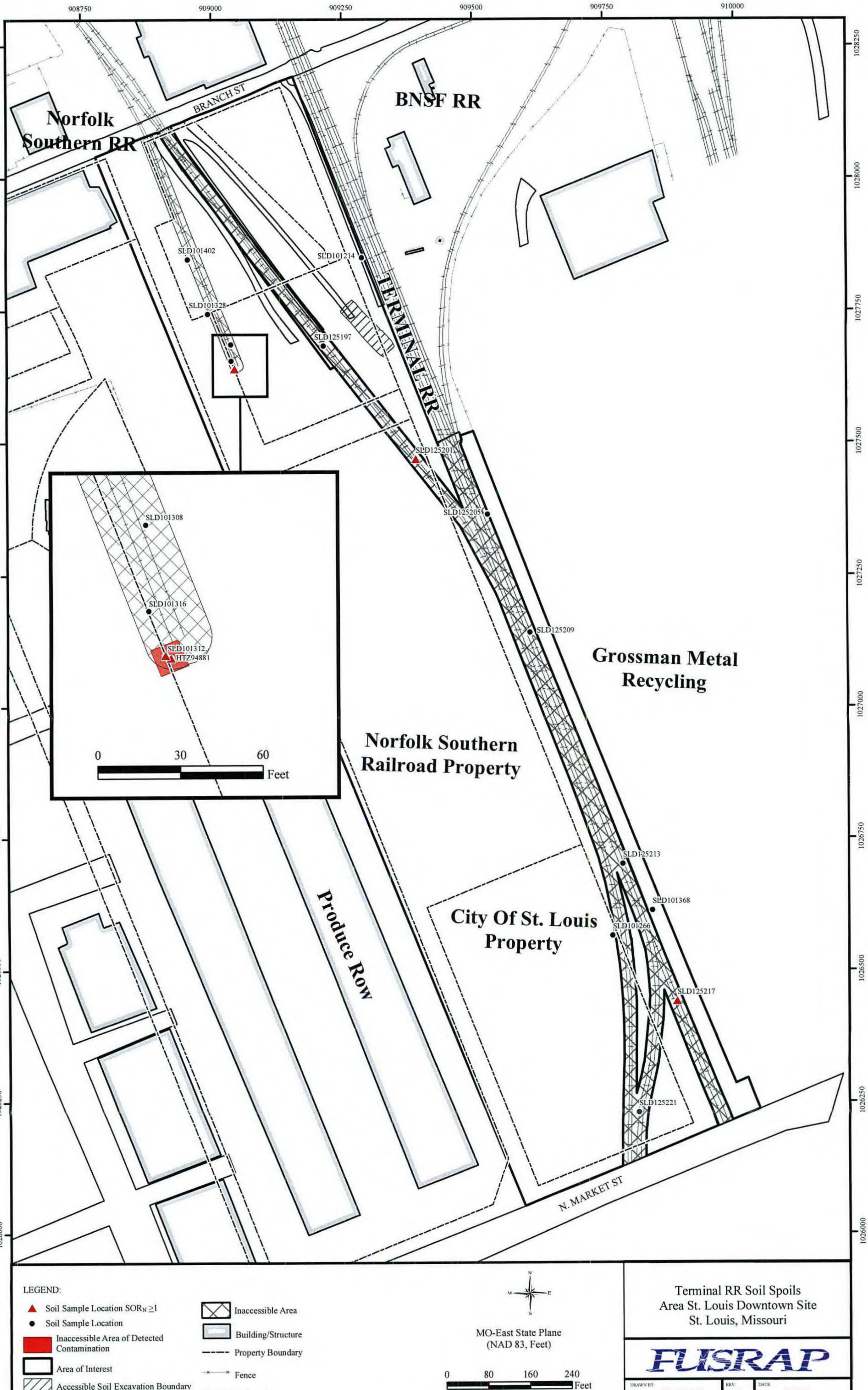


Figure C-17. Terminal RR Soil Spoils Area Soil Sampling Locations

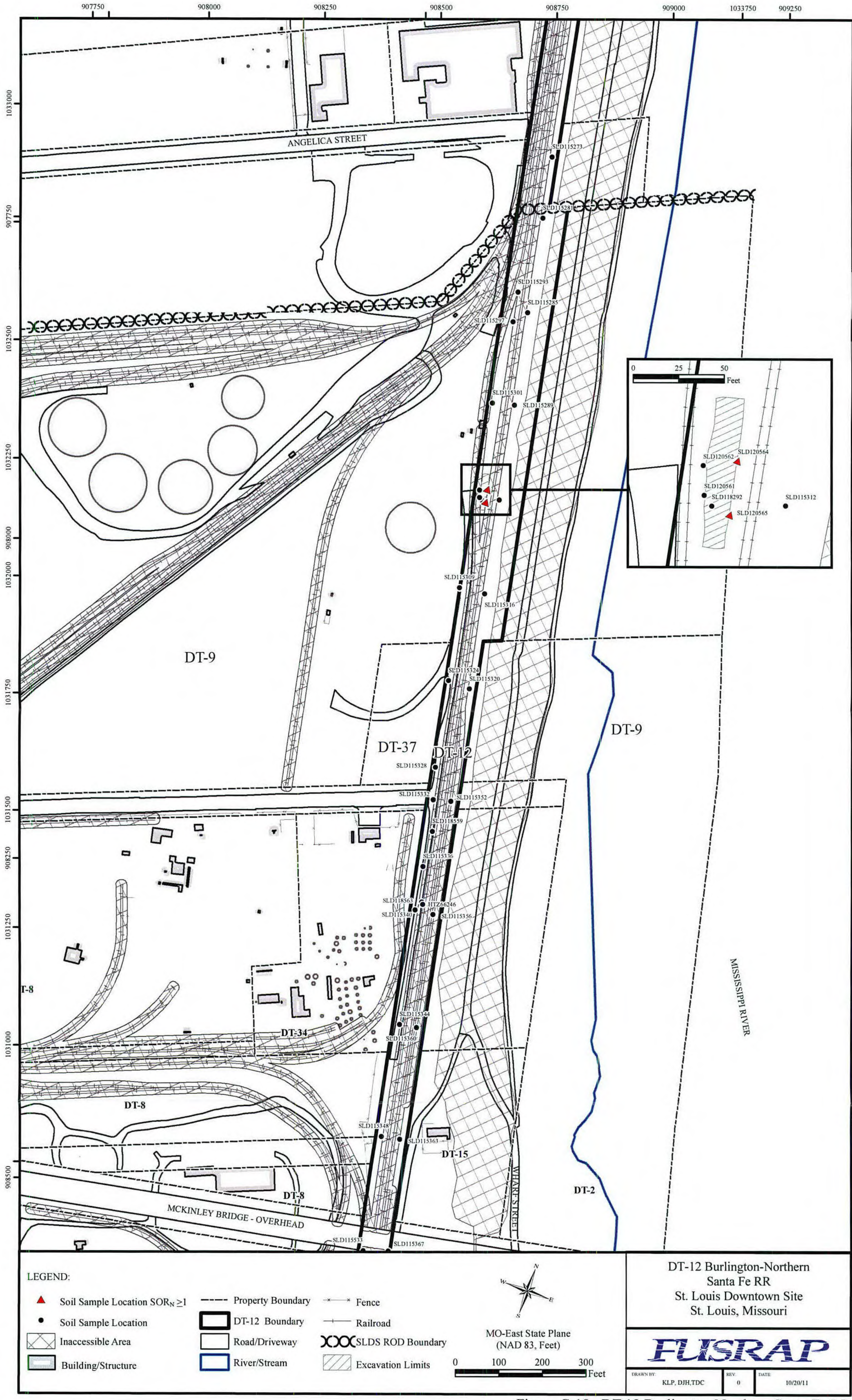


Figure C-18. DT-12 Burlington-Northern Santa Fe RR Soil Sampling Locations (North)

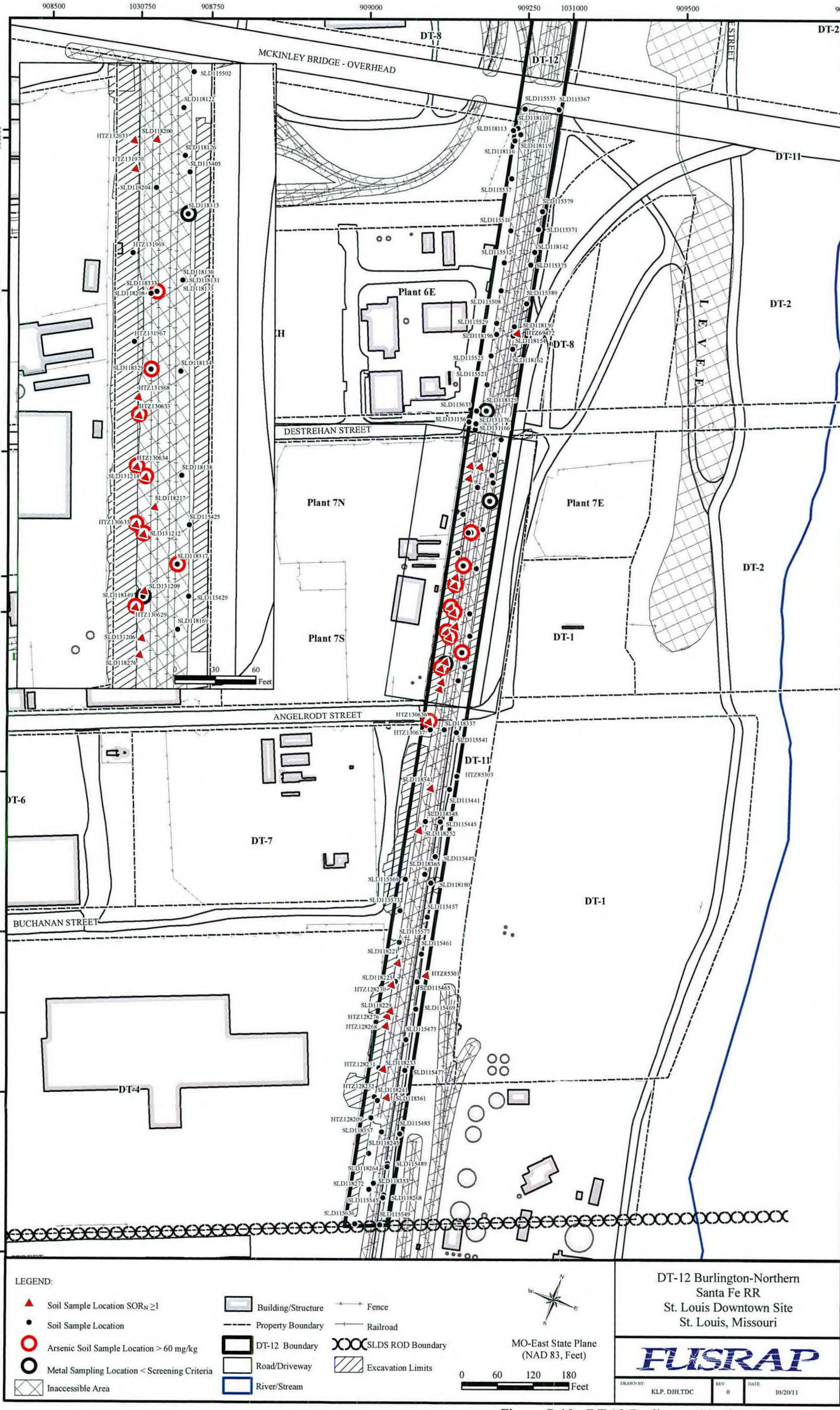


Figure C-19. DT-12 Burlington-Northern Santa Fe RR
Soil Sampling Locations (South)

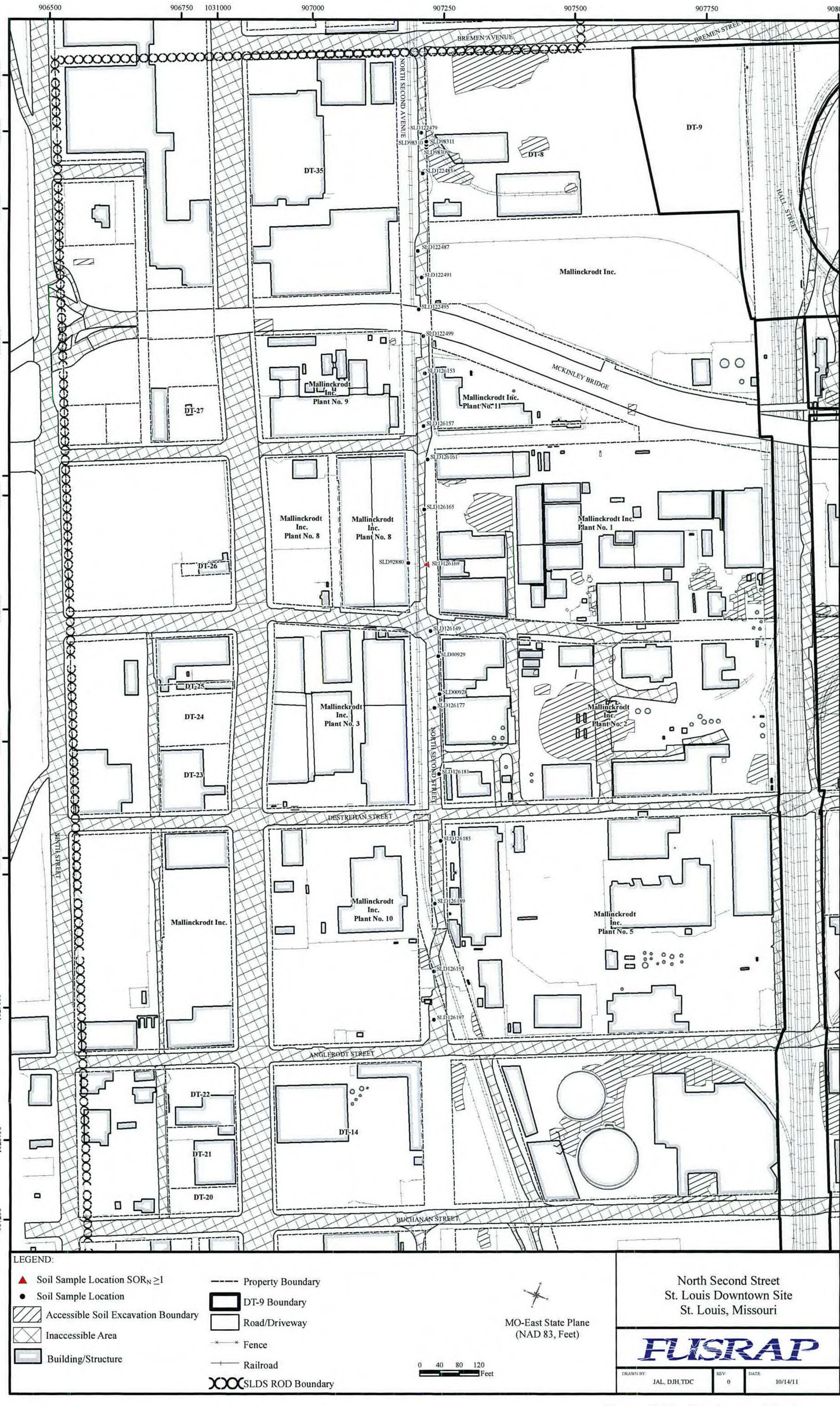


Figure C-20. Roadways - North Second Street Soil Sampling Locations

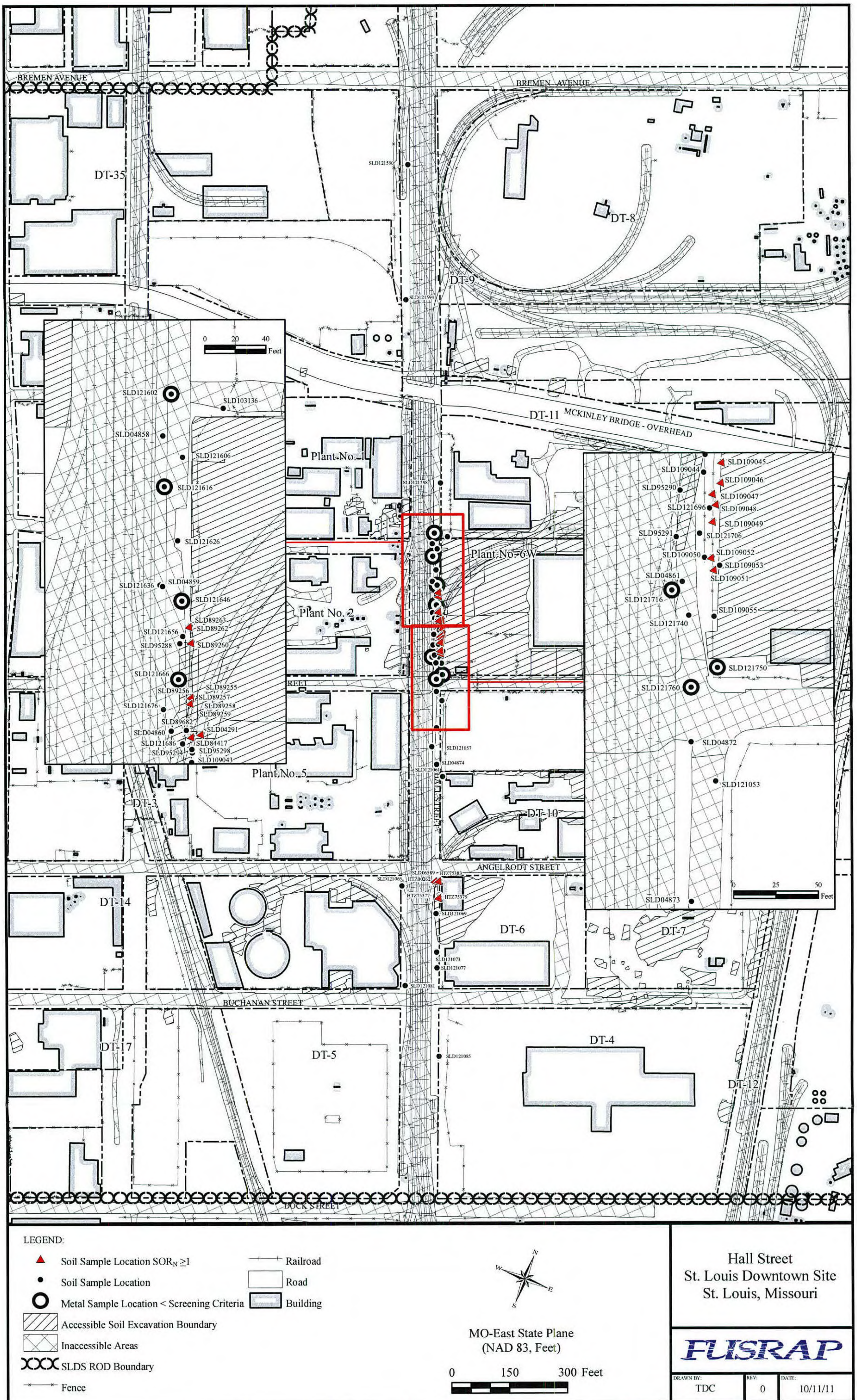


Figure C-21. Roadways – Hall Street
Soil Sampling Locations

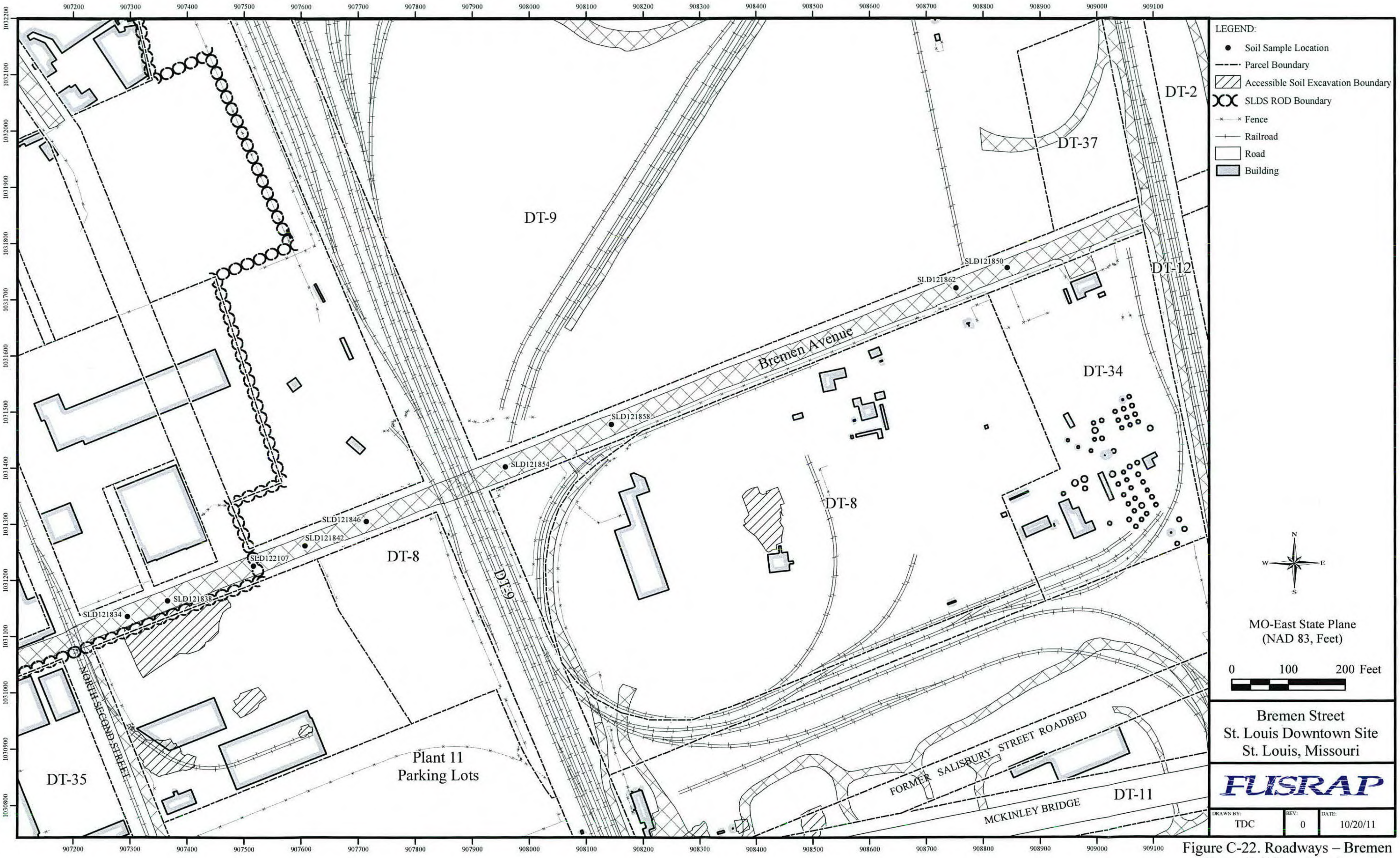

Figure C-22. Roadways – Bremen Street Soil Sampling Locations

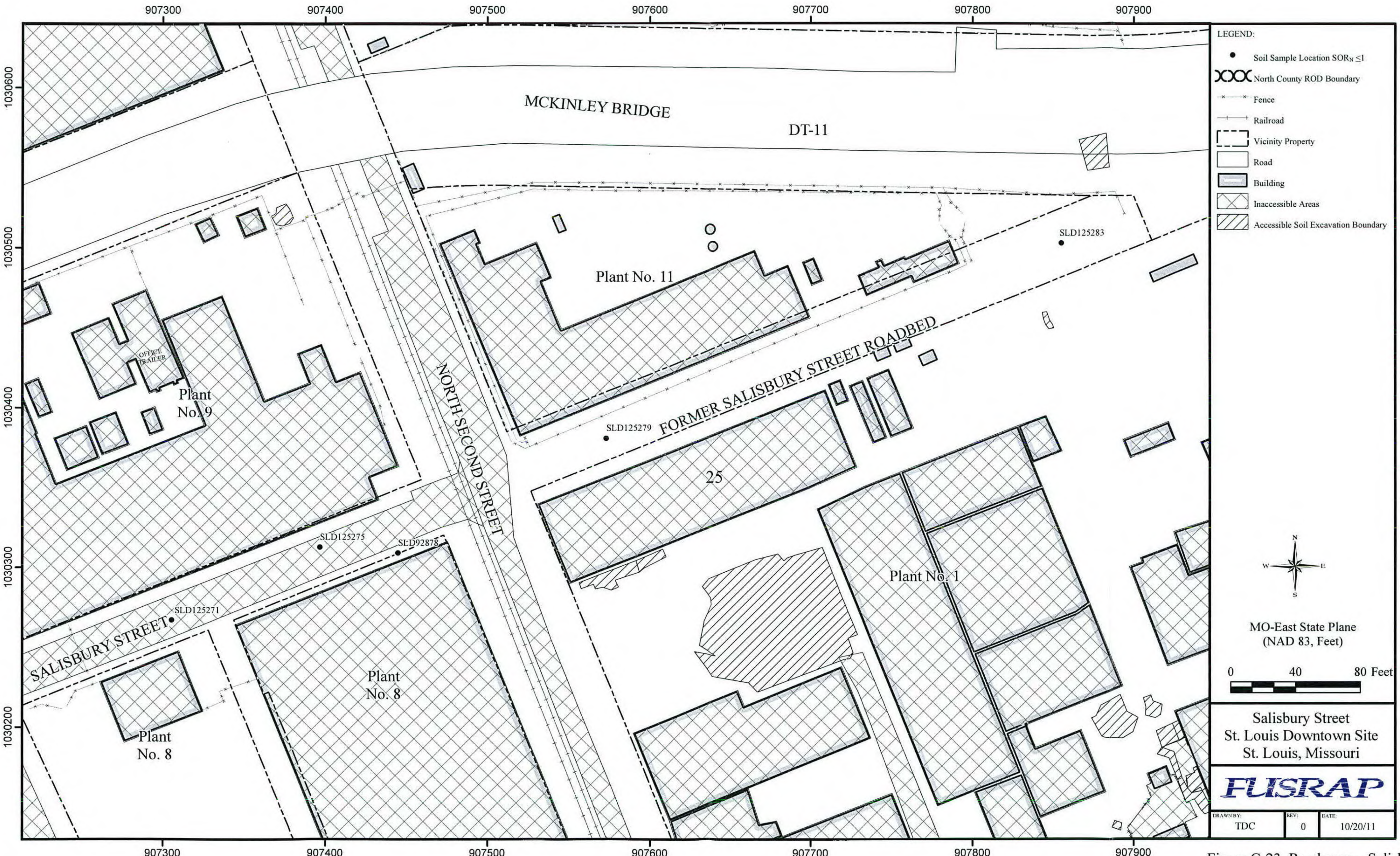


Figure C-23. Roadways – Salisbury Street Soil Sampling Locations

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Figure C-24. Roadways – Mallinckrodt Street
Soil Sampling Locations


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St. Louis Downtown Site
St. Louis, Missouri

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| JAL, DJH,TDC | 0 | 11/7/11 |

Figure C-25. Roadways – Destrehan Street Soil Sampling Locations

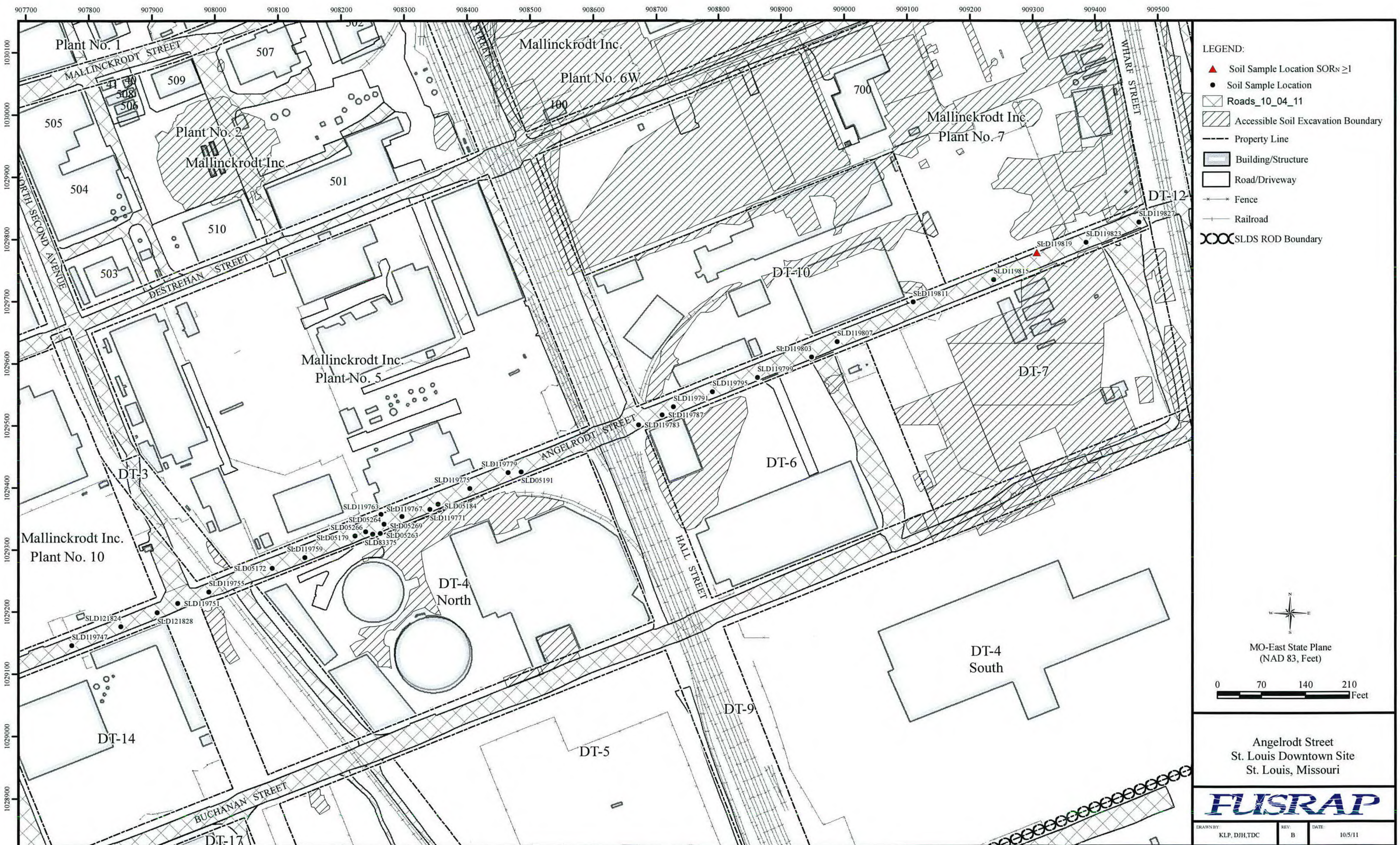


Figure C-26. Roadways – Angelrodt Street Soil Sampling Locations

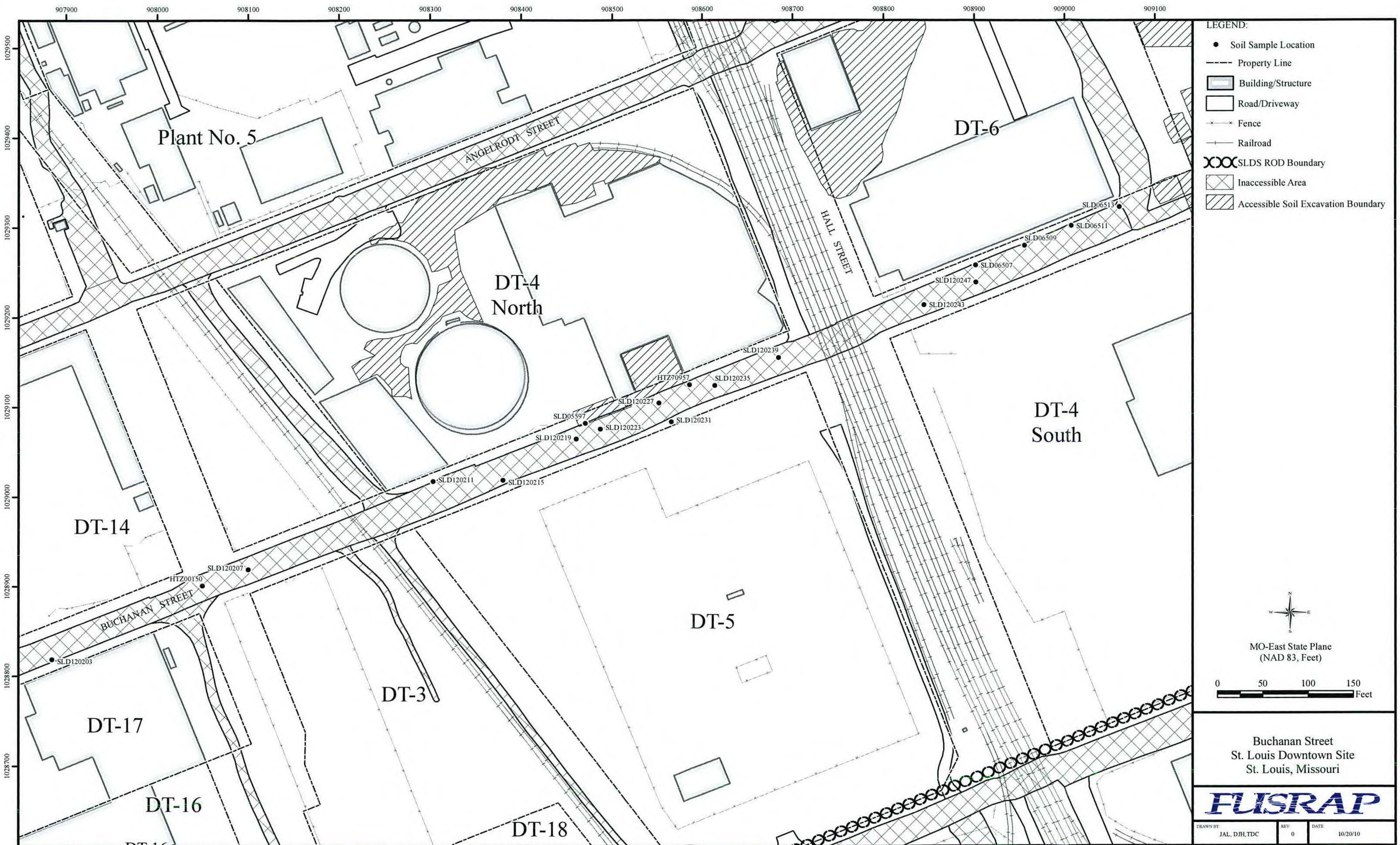


Figure C-27. Roadways – Buchanan Street Soil Sampling Locations

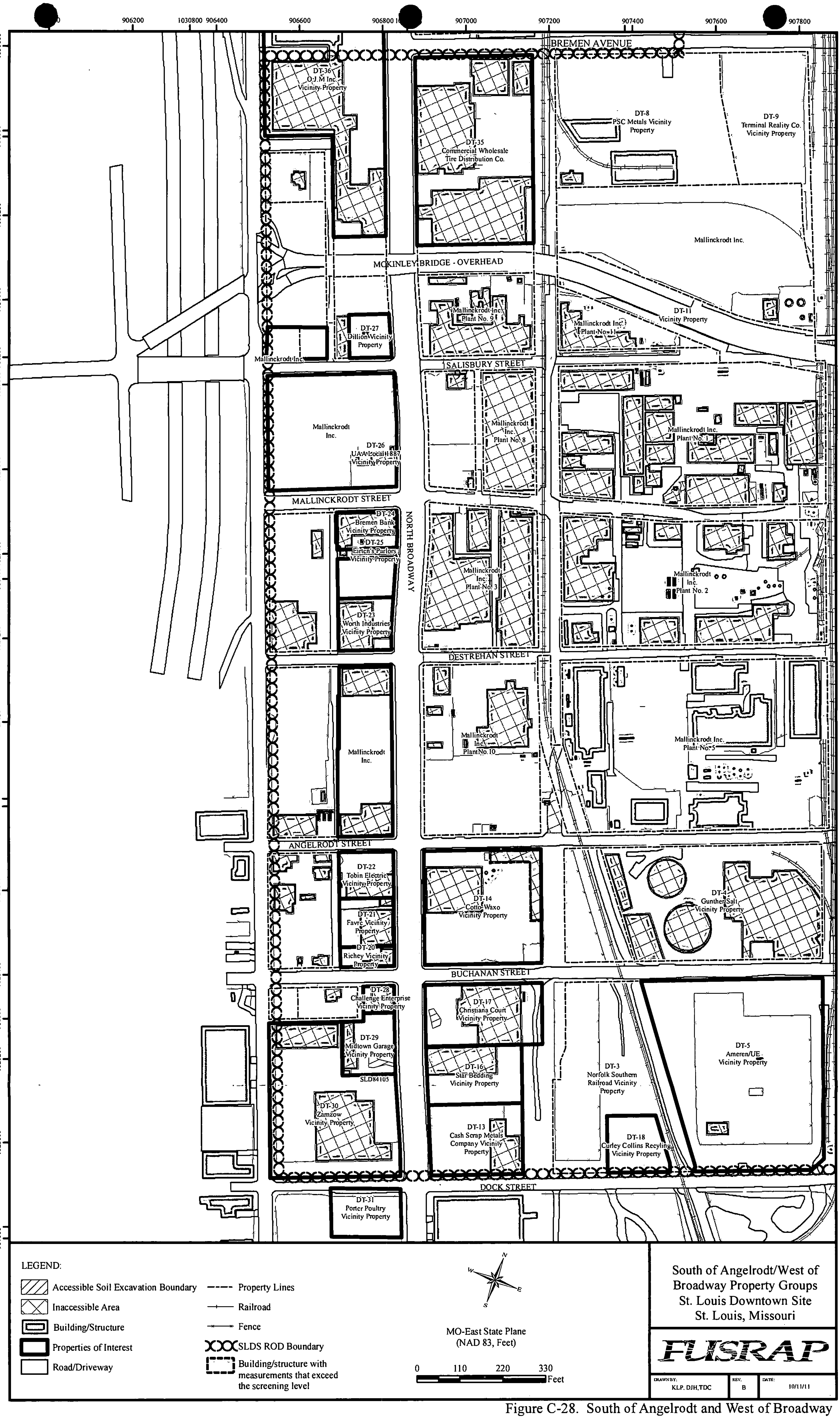


Figure C-28. South of Angelrodt and West of Broadway Property Groups Building Sampling Locations

# APPENDIX D

## Figures: Gamma Walkover Surveys of Inaccessible Soil Areas

## (On the CD-ROM on the Back Cover of this Report)

# APPENDIX E

## Data: Radiological and Metals Analytical Data Summaries for Inaccessible Soil by Property

## (On the CD-ROM on the Back Cover of this Report)

# APPENDIX F

## Data: Radiological Building Survey Results by Property and Building

## (On the CD-ROM on the Back Cover of this Report)

# APPENDIX G

## Figures: Extent of Radiological Contamination for Buildings

## LIST OF FIGURES

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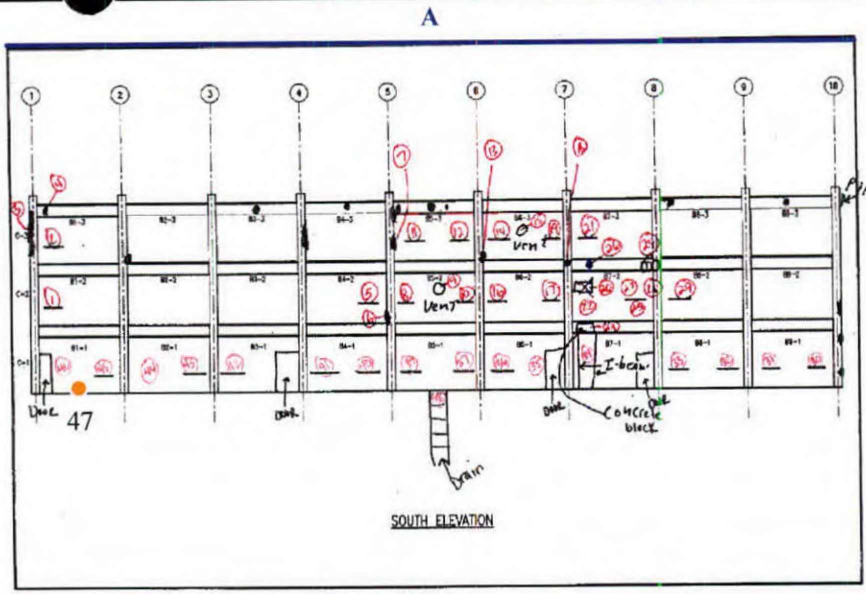


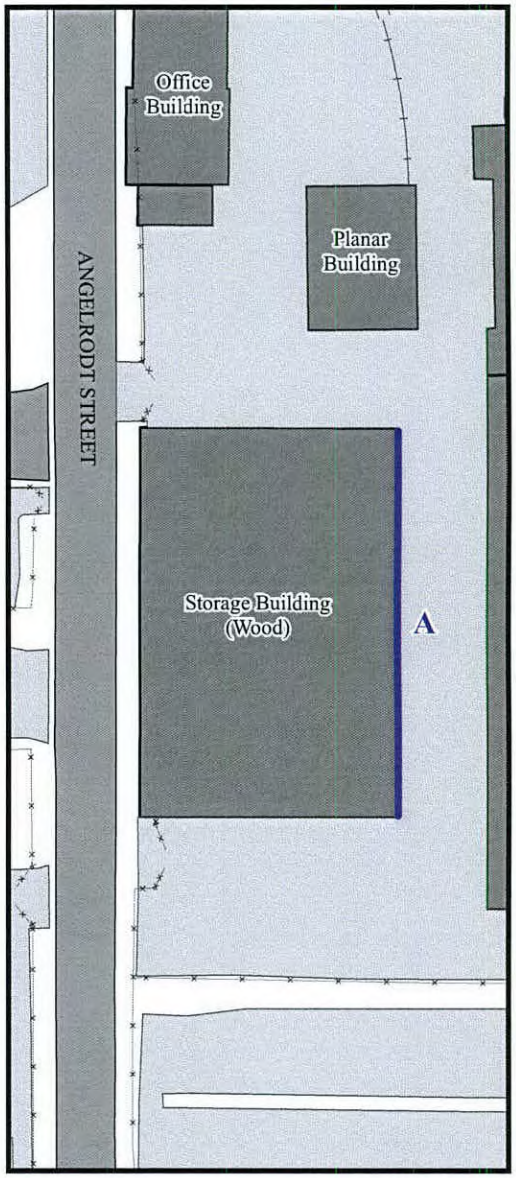

| Surface Measurement Results (dpm/100cm$^2$) |
|---|
| #47: 18,232 |

Location of Sample #47 obscured by metal shed. (See diagram above)


● Elevated measurement above alpha limit of 3900 dpm/100cm$^2$.

| | | | |
|---|---|---|---|
| FUSRAP | Property: Mallinckrodt Inc., Plant 1, St. Louis Downtown Site, St. Louis, Missouri | Drawn By: DJH, DLL | G-1 |
| | Subject: Building 25 Elevated Building Scan Location | Date: 09/30/10 | |

U:\GPS\SLDS\Inaccessible Areas\Projects\Building Scans\RevB\Figure G-1 Plant 1 Building 25 Exterior Elevated Sample.mxd


● Elevated measurement above alpha limit of 3900 dpm/100cm$^2$.

| Surface Measurement Results (dpm/100cm$^2$) | |
|---|---|
| #02: 17,752 | #13: 16,792 |
| #06: 18,728 | #74: 22,476 |
| #09: 16,259 | #77: 19,196 |
| #11: 15,863 | |

FUSRAP

Property:
DT-10 Thomas and Proetz Lumber, St. Louis Downtown Site, St. Louis, Missouri

Subject:
North Wall of Wood Storage Building

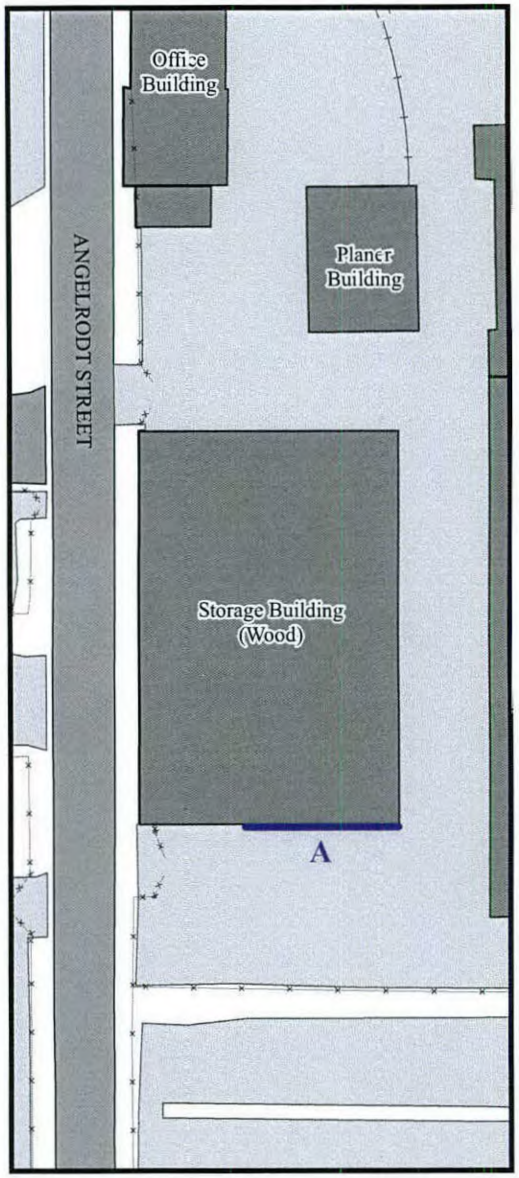
Drawn By:
DJH, DLL

Date:
09/30/10

G-2

U:\GPS\SLDS\Inaccessible Areas\Projects\Building Scans\RevB\Figure G-2 DT-10 North Wall-Wood Storage Building.mxd

A


● Elevated measurement above alpha limit of 3900 dpm/100cm$^2$.

| Surface Measurement Results (dpm/100cm$^2$) |
|---|
| #19: 4,419 |

| | | |
|---|---|---|
| FUSRAP | Property: DT-10 Thomas and Proetz Lumber, St. Louis Downtown Site, St. Louis, Missouri | Drawn By: DJH, DLL |
| | Subject: East Wall of Wood Storage Building | Date: 09/30/10 |

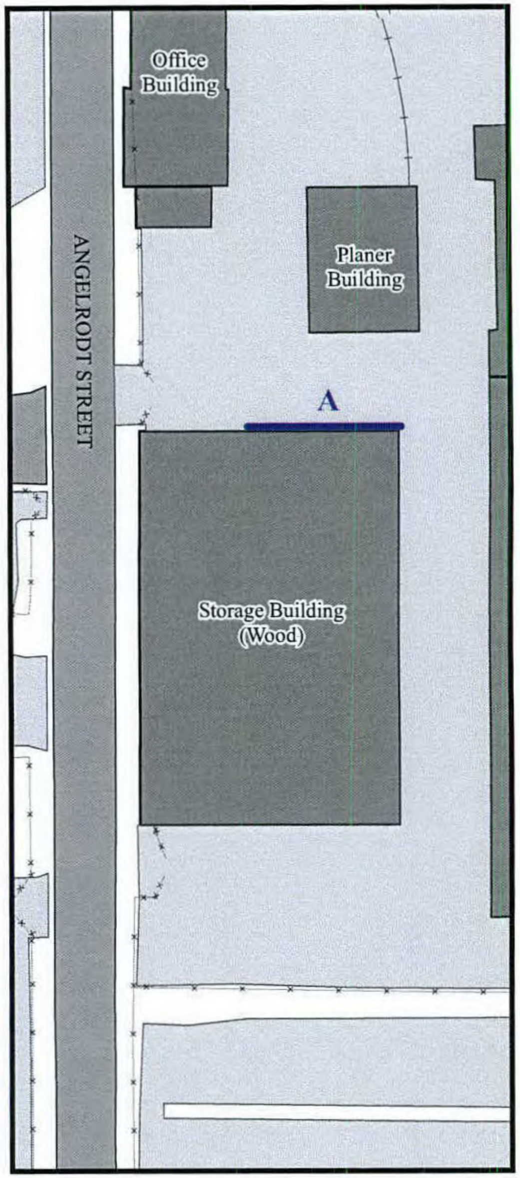
G-3

U:\GPS\SLDS\Inaccessible Areas\Projects\Building Scans\RevB\Figure G-3 DT-10 East Wall-Wood Storage Building.mxd

A


● Elevated measurement above alpha limit of 3900 dpm/100cm$^2$.

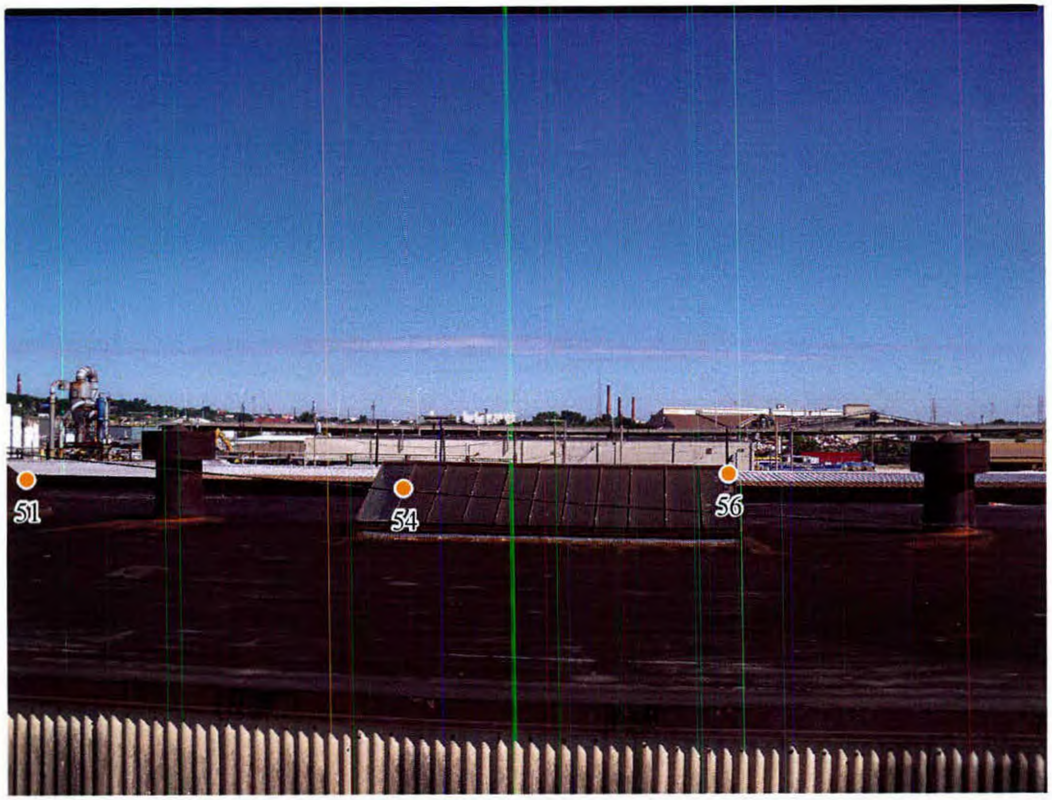
| Surface Measurement Results (dpm/100cm$^2$) | |
|---|---|
| #62: 6,609 | #67: 6,329 |
| #65: 4,116 | #68: 5,809 |




| | | | | |
|---|---|---|---|---|
| FUSRAP | Property: DT-10 Thomas and Proetz Lumber, St. Louis Downtown Site, St. Louis, Missouri | | Drawn By: DJH, DLL | G-4 |
| | Subject: West Wall of Wood Storage Building | | Date: 09/30/10 | |

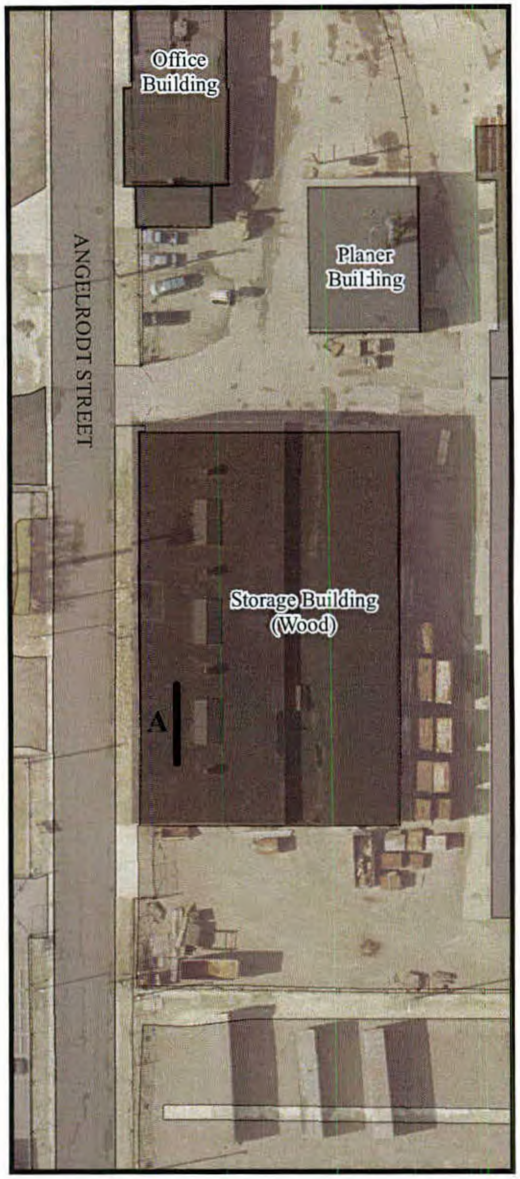
U:\GPS\SLDS\Inaccessible Areas\Projects\Building Scans\RevB\Figure G-4 DT-10 West Wall-Wood Storage Building.mxd

A




● Elevated measurement above alpha limit of 3900 dpm/100cm$^2$.

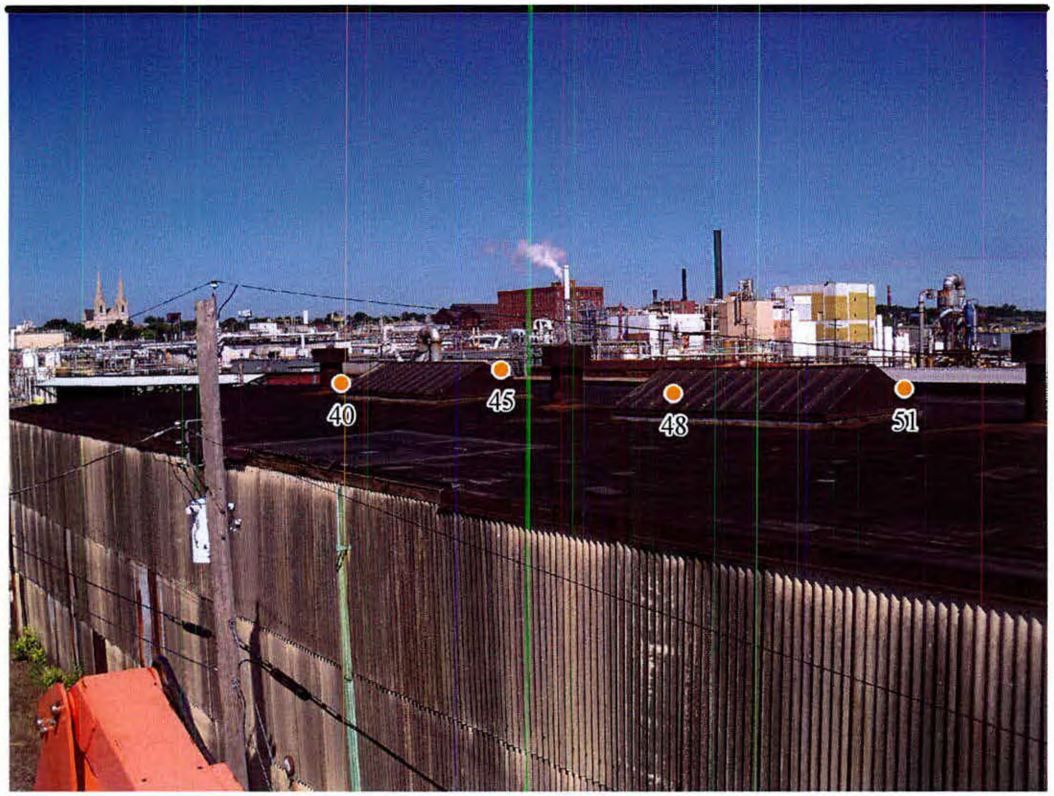
| Surface Measurement Results (dpm/100cm$^2$) |
|---|
| #51: 5,709<br>#54: 6,364<br>#56: 7,050 |




| | | | | |
|---|---|---|---|---|
| FUSRAP | Property: DT-10 Thomas and Proetz Lumber, St. Louis Downtown Site, St. Louis, Missouri | | Drawn By: DJH, DLL | G-5 |
| | Subject: Roof of Wood Storage Building - Facing North | | Date: 09/30/10 | |

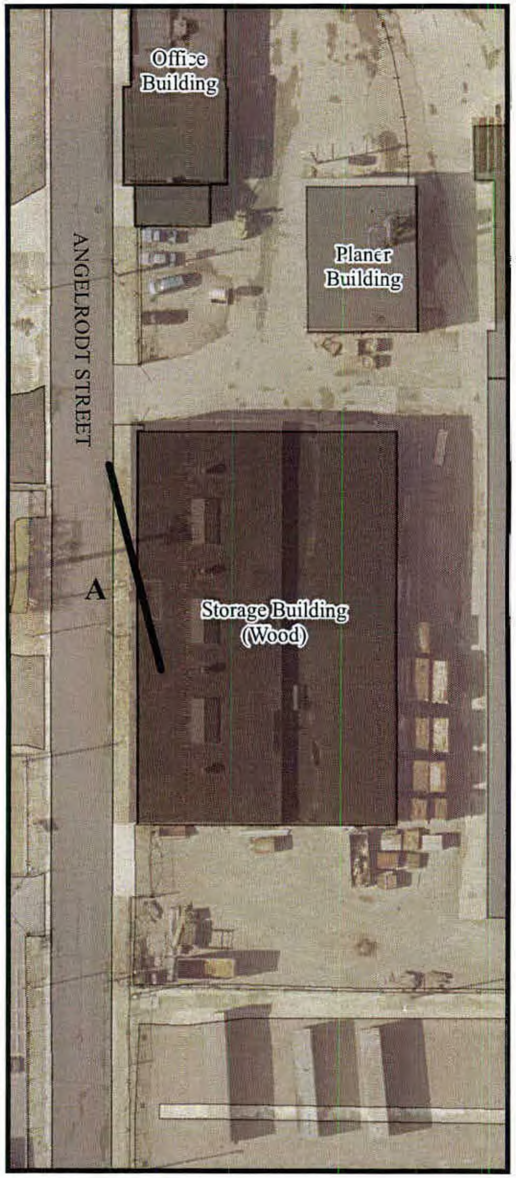
U:\GPS\SLDS\Inaccessible Areas\Projects\Building Scans\RevB\Figure G-5 DT-10 Roof of Wood Storage Building - Facing North.mxd

A




● Elevated measurement above alpha limit of 3900 dpm/100cm$^2$.

| Surface Measurement Results (dpm/100cm$^2$) | |
|---|---|
| #40: 5,831 | #48: 6,121 |
| #45: 5,557 | #51: 5,709 |




U:\GPS\SLDS\Inaccessible Areas\Projects\Building Scans\RevB\Figure G-6 DT-10 Roof of Wood Storage Building - Facing West.mxd

FUSRAP

Property:
DT-10 Thomas and Proetz Lumber, St. Louis Downtown Site, St. Louis, Missouri

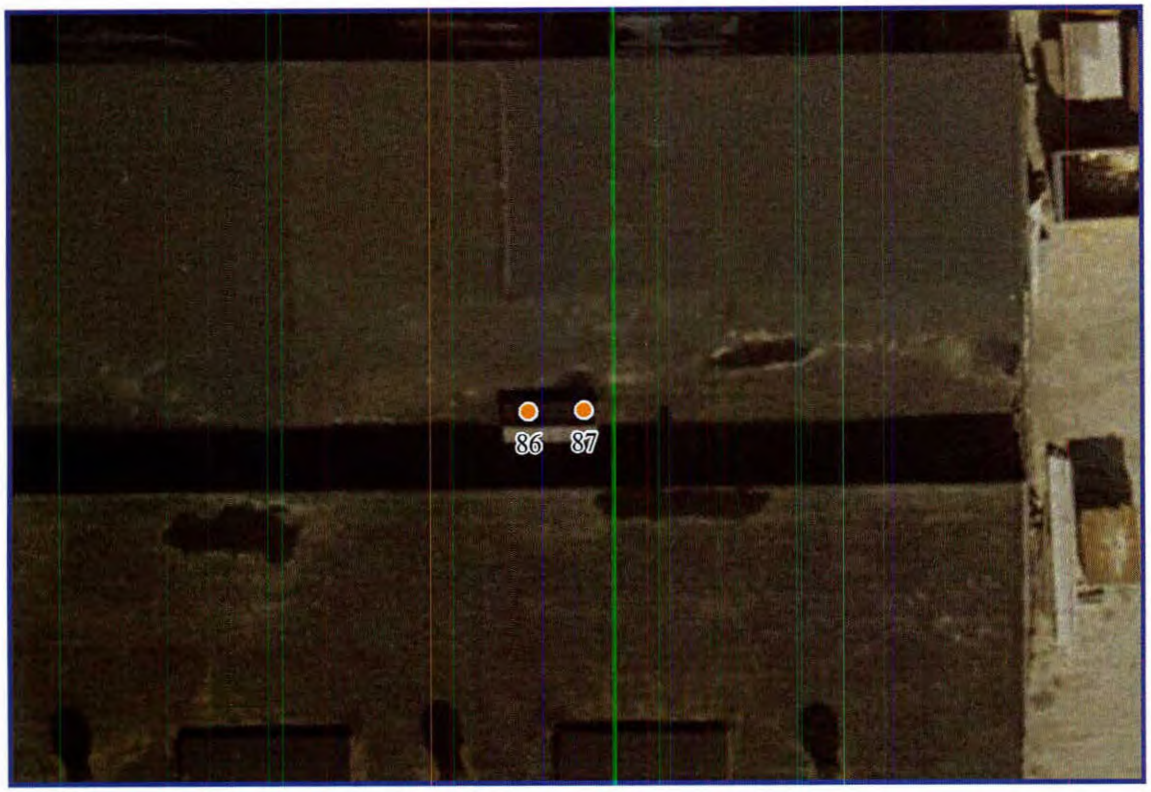
Subject:
Roof of Wood Storage Building - Facing West

Drawn By:
DJH, DLL

Date:
09/30/10

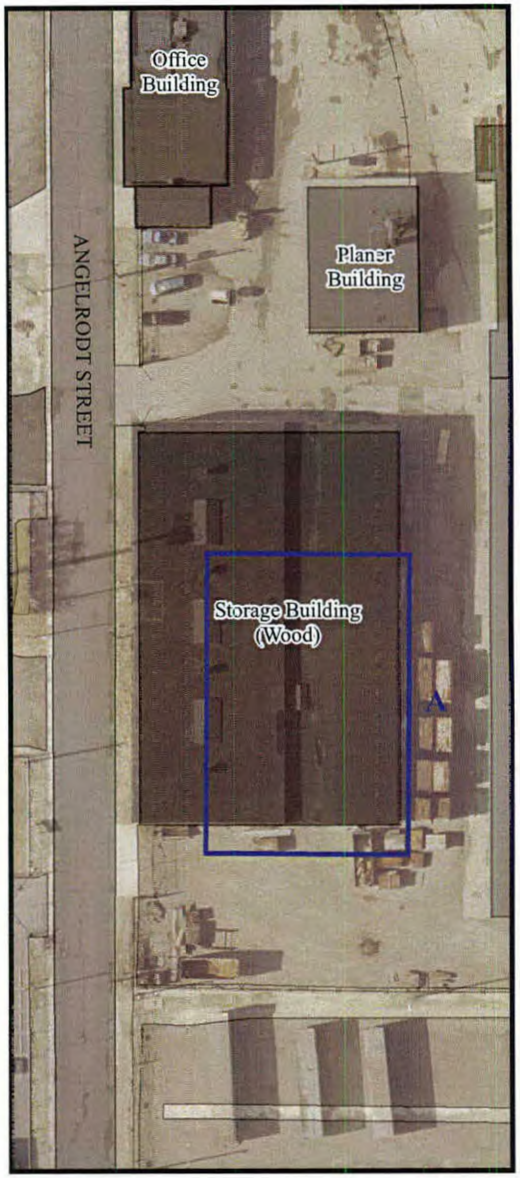
G-6

A




● Elevated measurement above alpha limit of 3900 dpm/100cm$^2$.

| Surface Measurement Results (dpm/100cm$^2$) |
|---|
| #86: 5,333<br>#87: 7,335 |



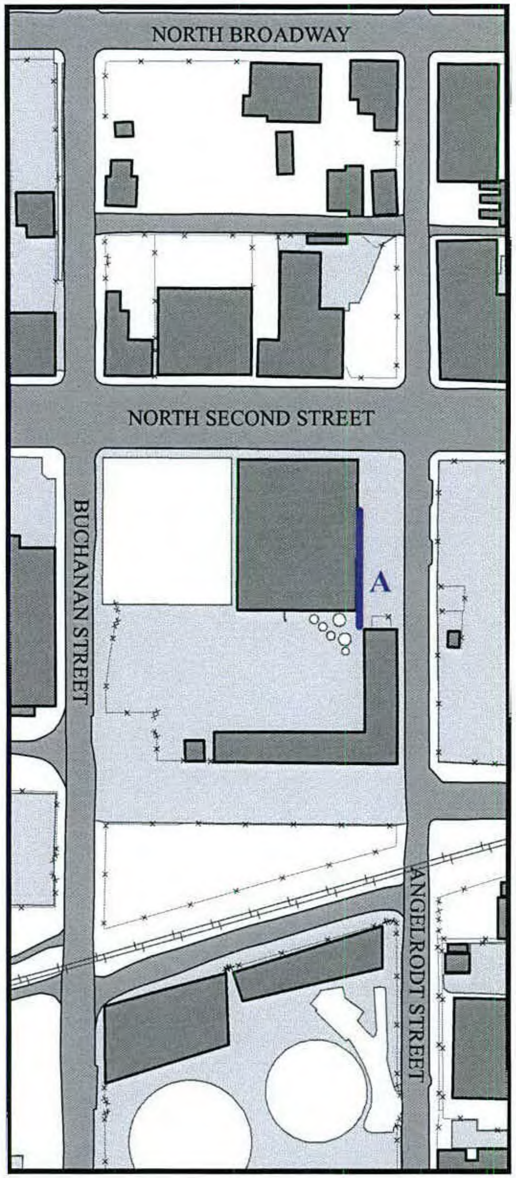

U:\GPS\SLDS\Inaccessible Areas\Projects\Building Scans\RevB\Figure G-7 DT-10 Roof of Wood Storage Building.mxd

| FUSRAP | Property: DT-10 Thomas and Proetz Lumber, St. Louis Downtown Site, St. Louis, Missouri | | Drawn By: DJH, DLL | G-7 |
|---|---|---|---|---|
| | Subject: Roof of Wood Storage Building | | Date: 09/30/10 | |

A


● Elevated measurement above alpha limit of 3900 dpm/100cm$^2$.

| Surface Measurement Results (dpm/100cm$^2$) |
|---|
| #40: 4,760 |




U:\GPS\SLDS\Inaccessible Areas\Projects\Building Scans\RevB\Figure G-8 DT-14 Support Beam.mxd

FUSRAP

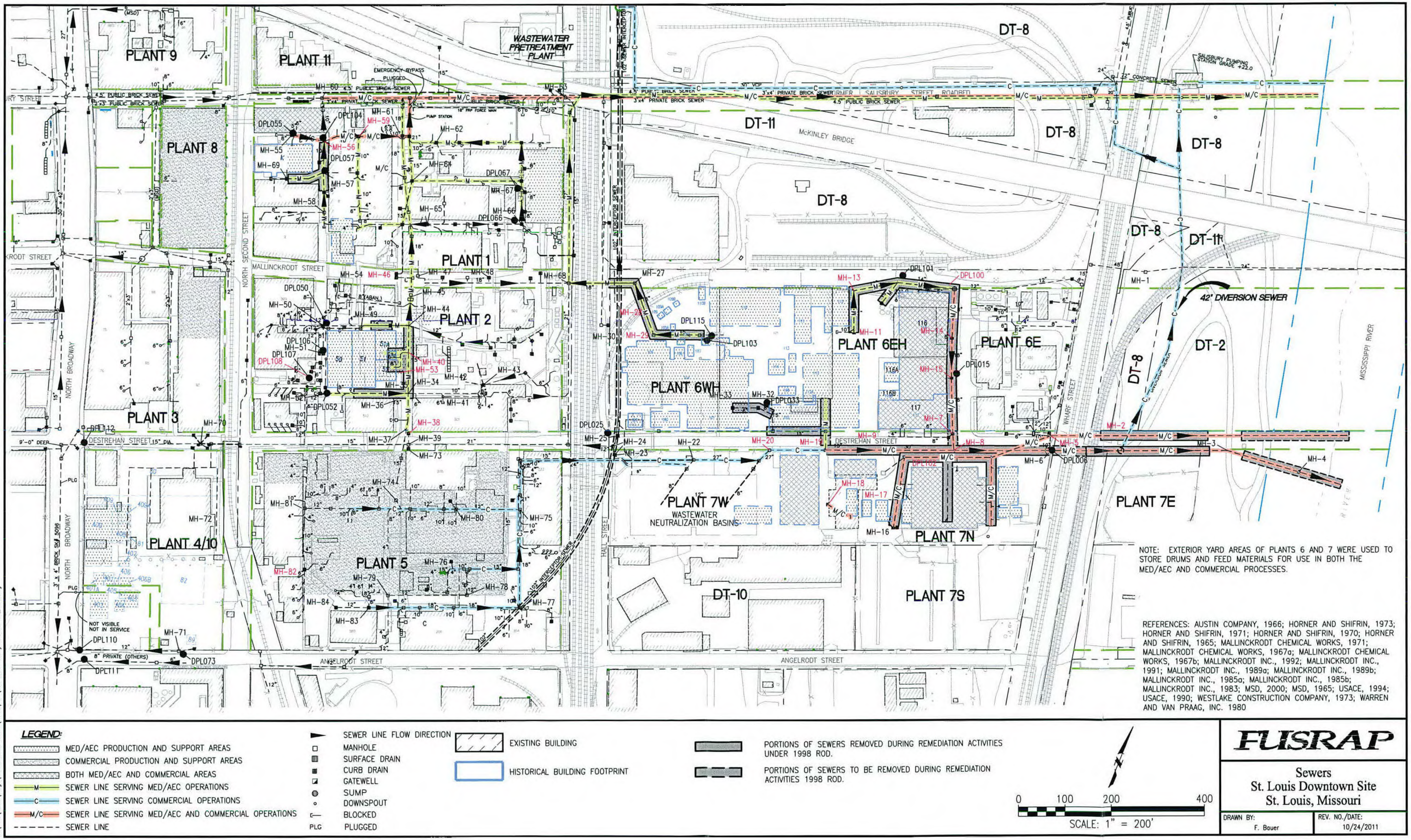
Property:
DT-14 Cotto Waxo, St. Louis Downtown Site, St. Louis, Missouri

Subject:
Support Beam Between Buildings

Drawn By:
DJH, DLL

Date:
09/30/10

G-8




U:\CAD\SLDS\Dwgs\Inaccessible Areas\RI Report\SLDSSewerStudyMEDAEC-CT_R00.dwg

Figure H-1. Map of Sewer System

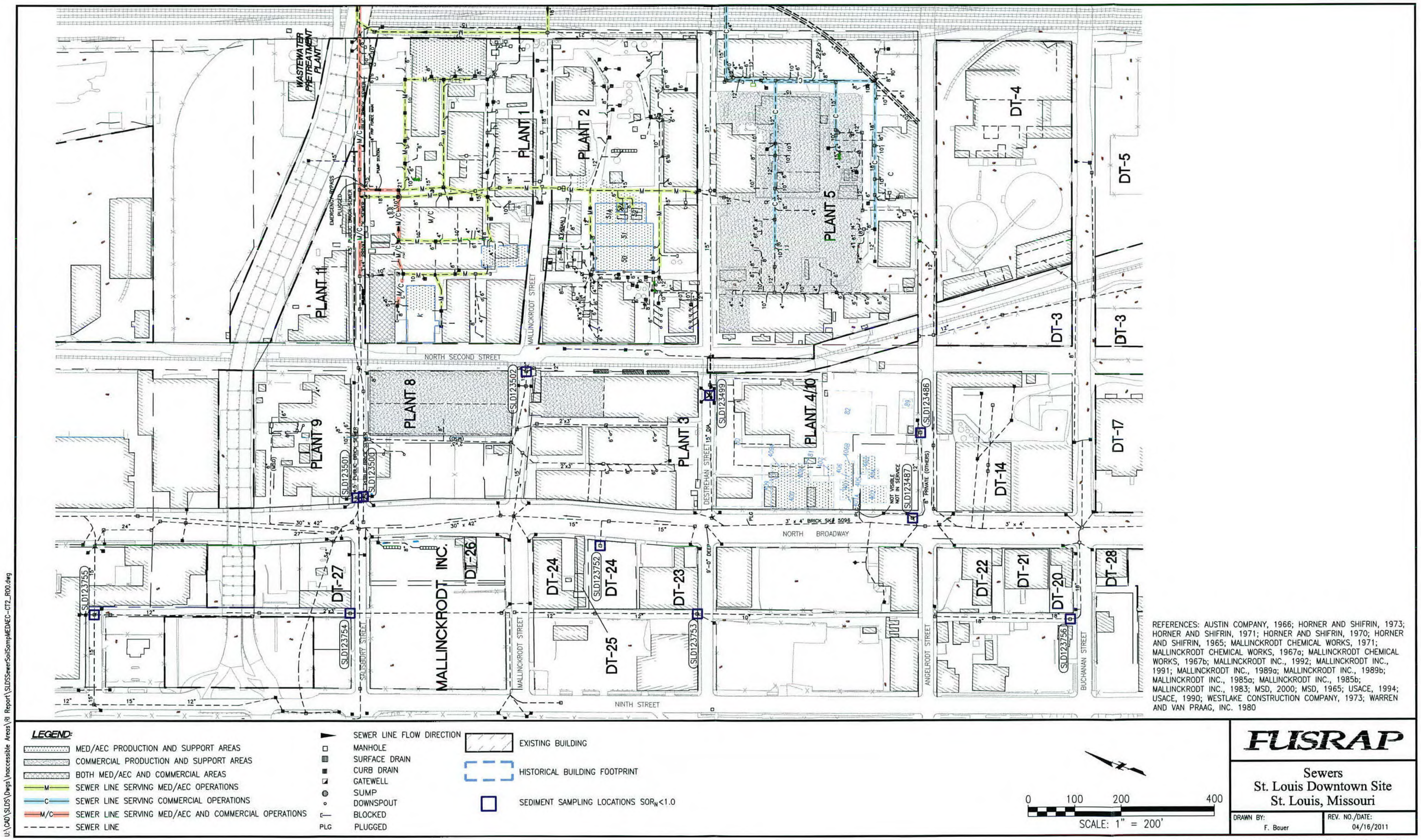



Figure H-2. Upstream Sediment Sampling Locations for Sewers at the SLDS

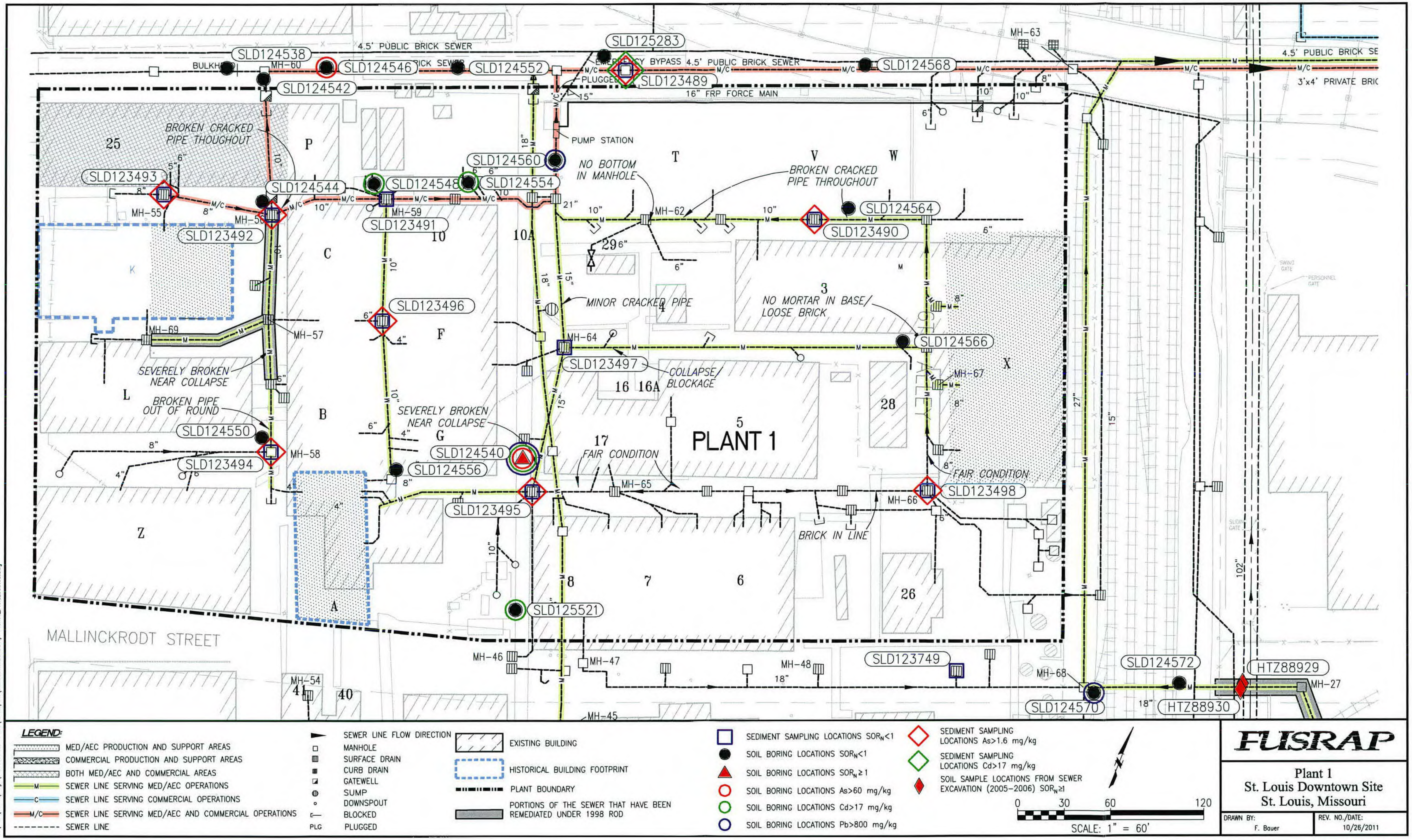



Figure H-3. Sediment and Soil Sampling Locations for Sewers at Plant 1

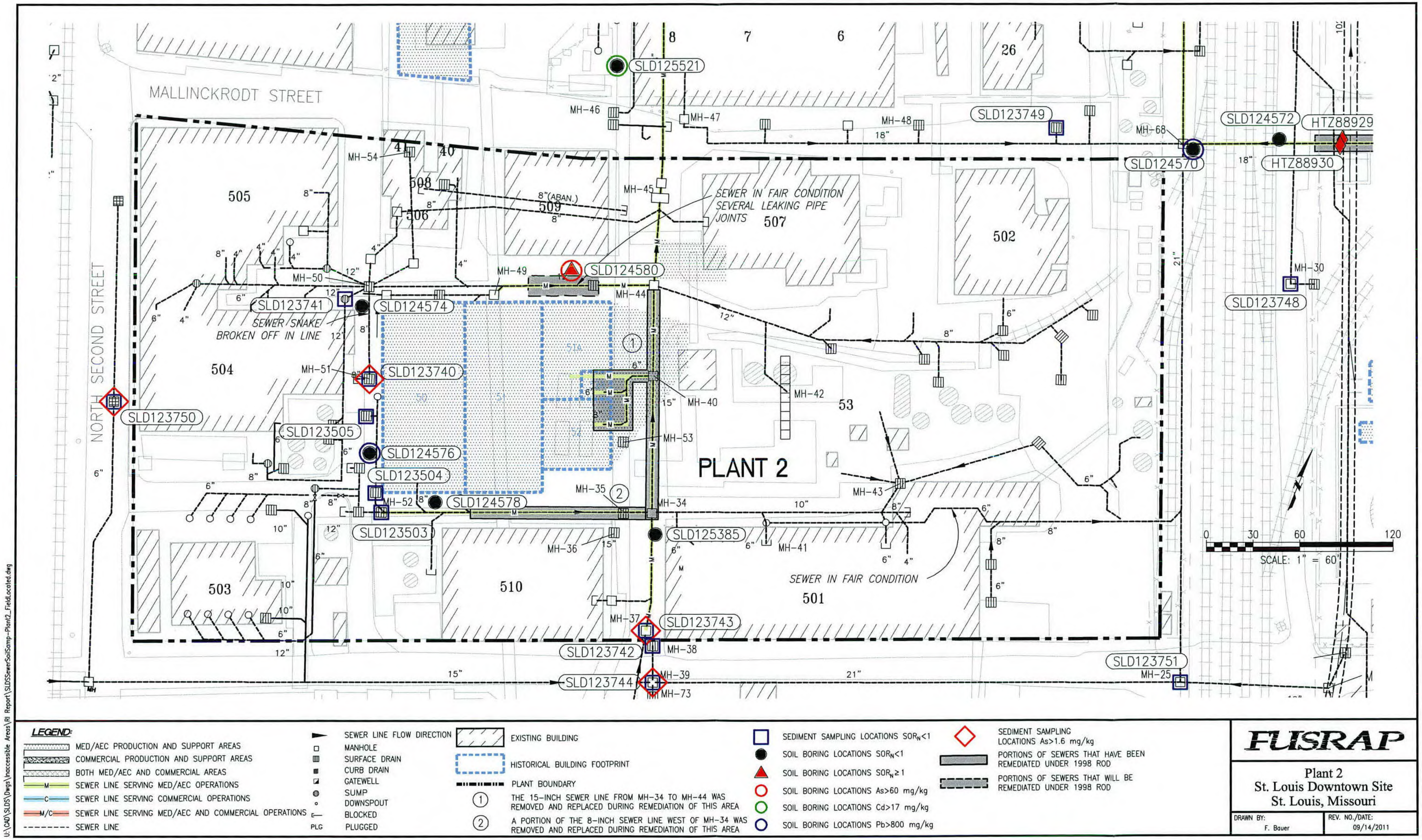



Figure H-4. Sediment and Soil Sampling Locations for Sewers at Plant 2

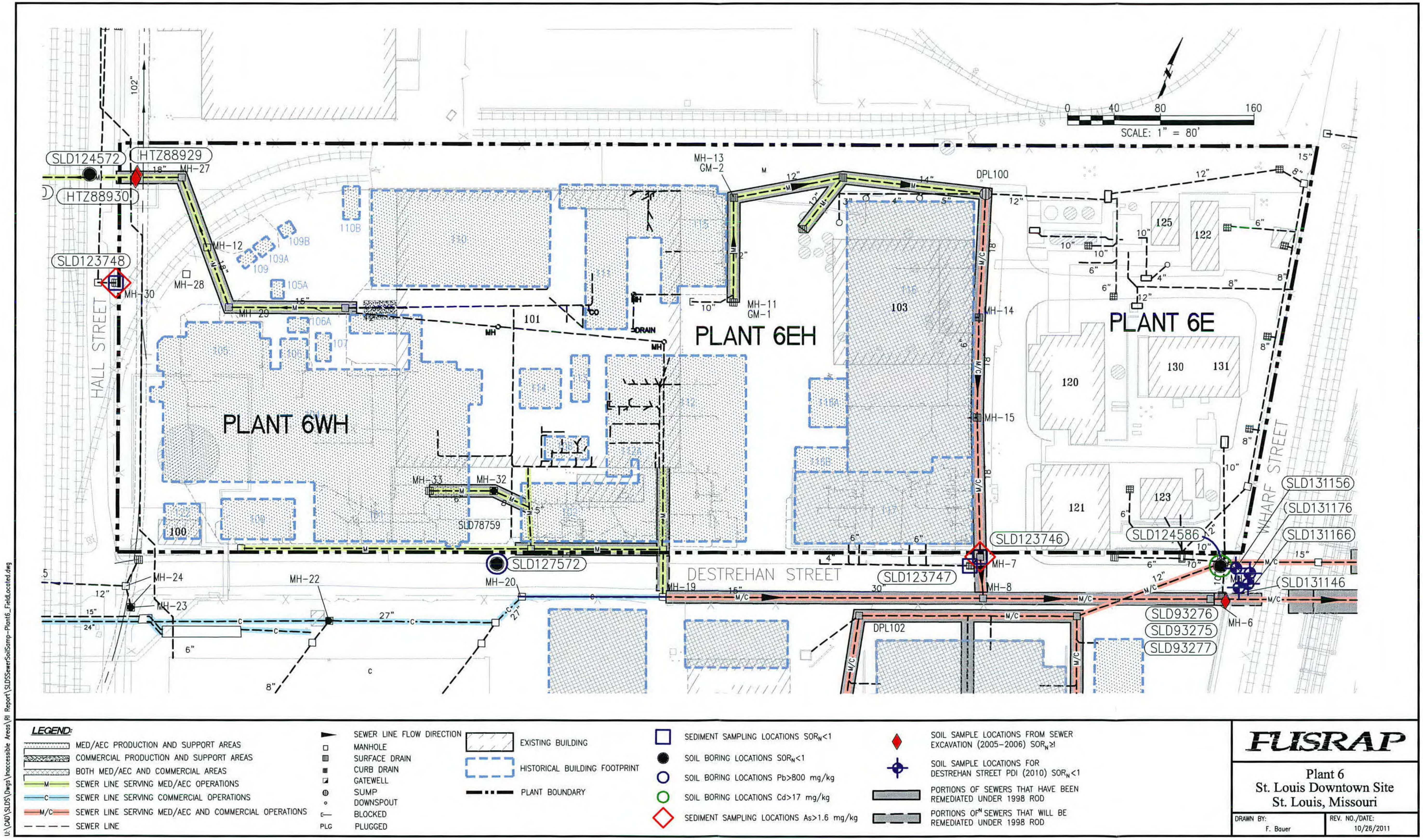
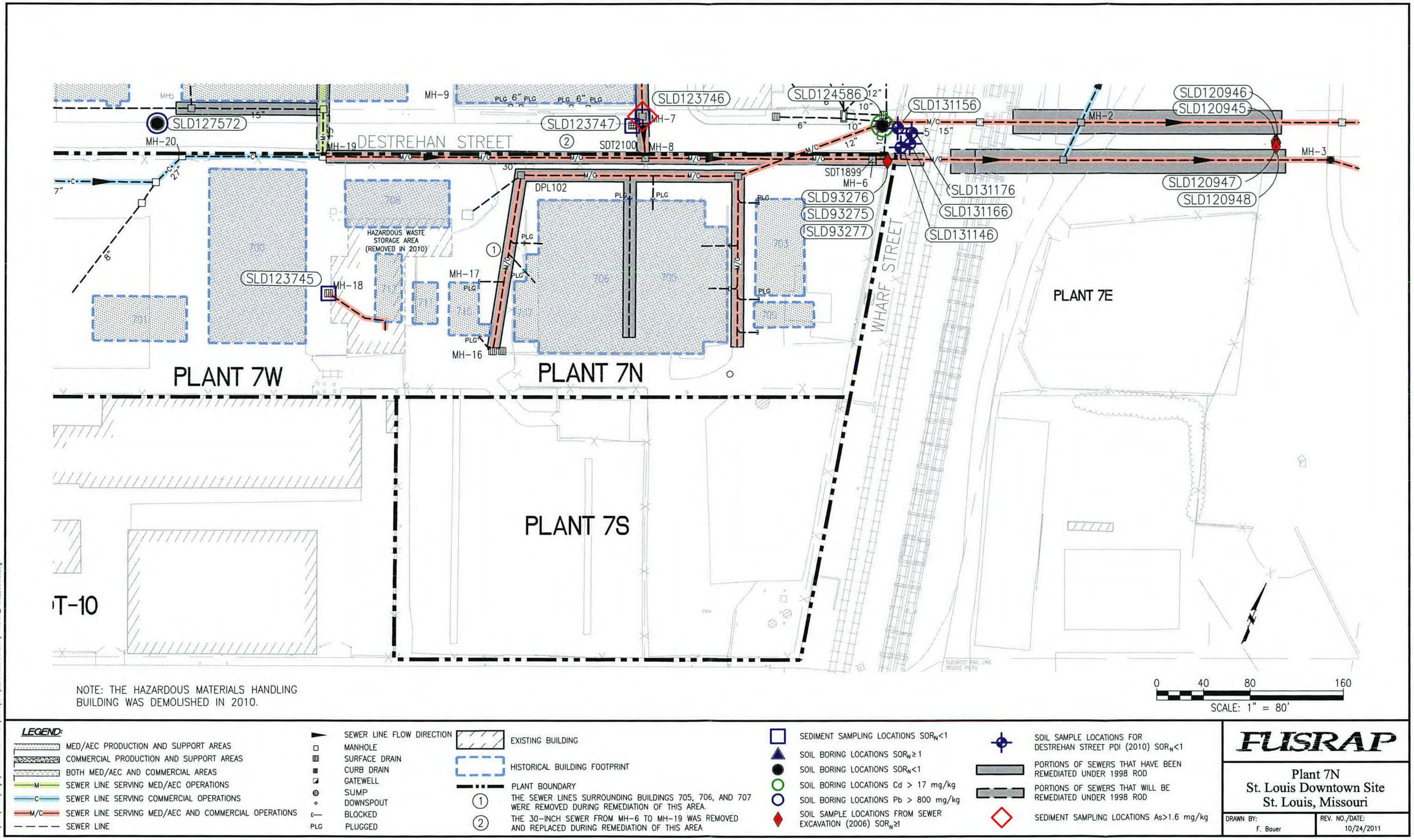
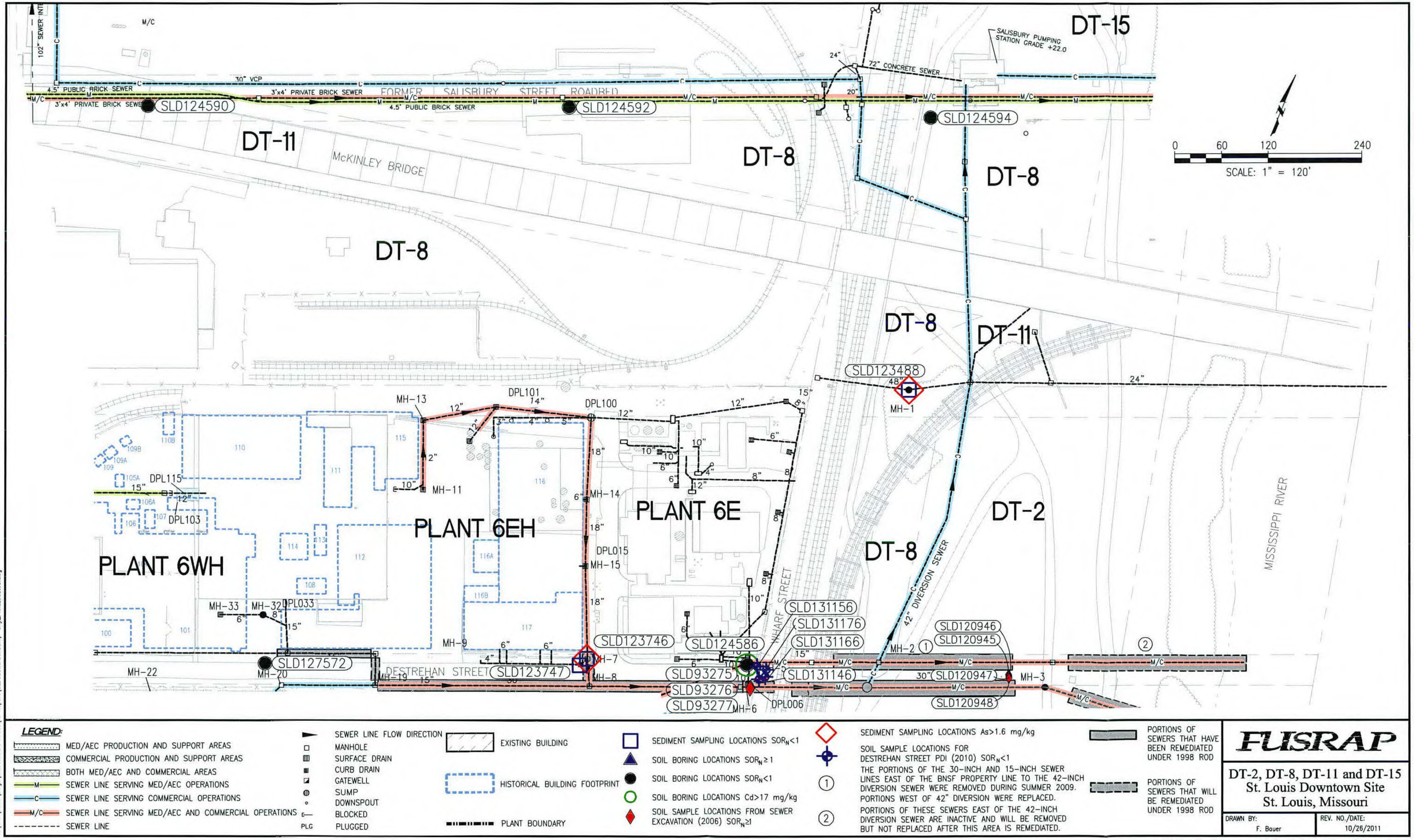



Figure H-5. Sediment and Soil Sampling Locations for Sewers at Plant 6




U:\CAD\SLDS\Dwgs\Inaccessible Areas\RI Report\SLDSSewerSoilSamp-Plant7_FieldLocated.dwg

Figure H-6. Sediment and Soil Sampling at Plant 7N, the BNSF RR VP (DT-12), and the Levee at the City Property VP (DT-2)




J:\CAD\SLDS\Dwgs\Inaccessible Areas\RI Report\SLDSSewerSoilSamp-City_FieldLocated.dwg

Figure H-7. Sediment and Soil Sampling Locations for Sewers at PSC Metals, Inc. VP (DT-8) and the Illinois DOT and Missouri DOT VP (DT-11)

# APPENDIX H

## Figures: Extent of Contamination for Radiological and Metals Sampling for Sewers

## LIST OF FIGURES

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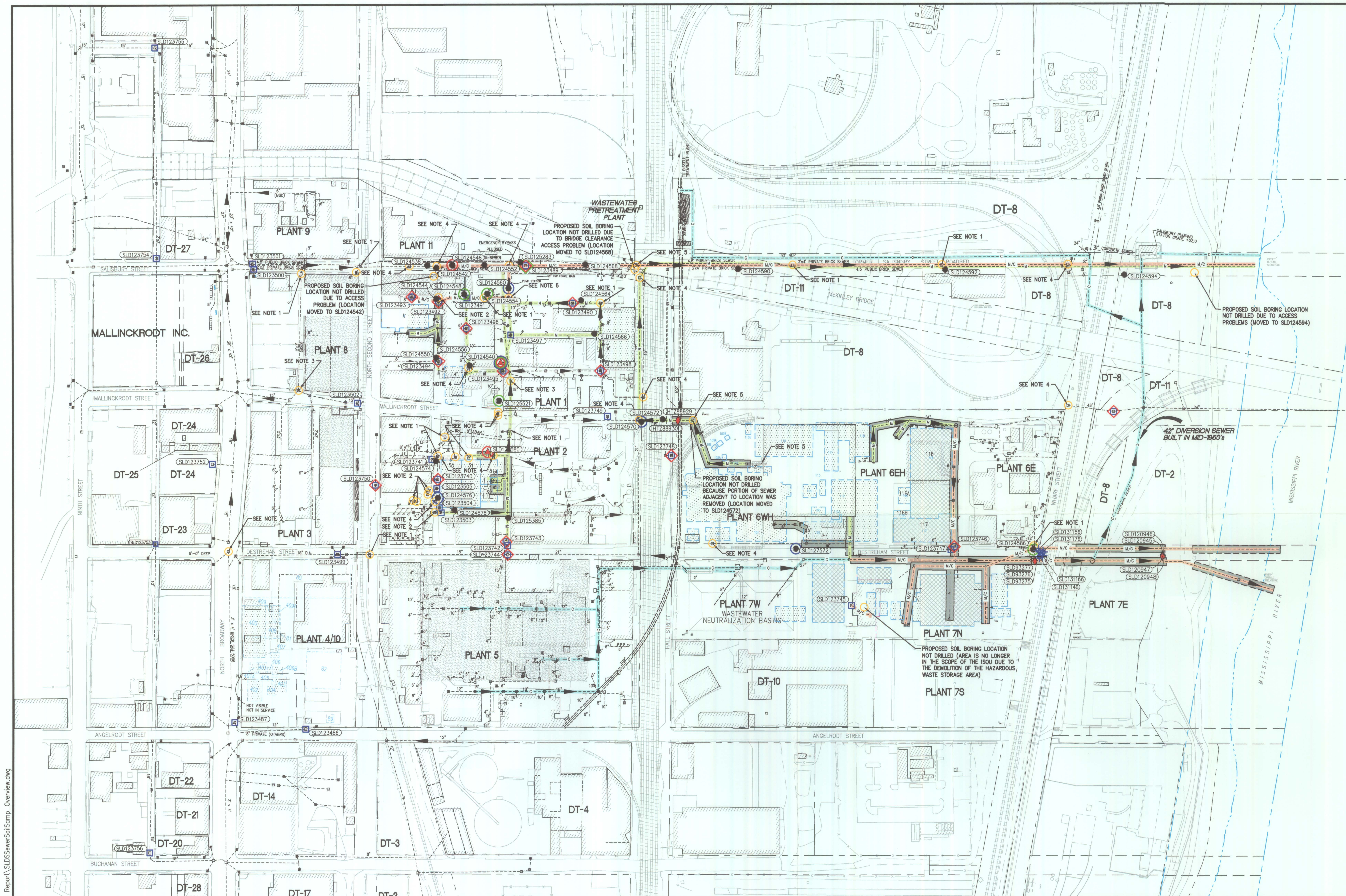


SAMPLING NOTES:

1. PROPOSED SEDIMENT SAMPLING LOCATION NOT SAMPLED DUE TO LACK OF SEDIMENT.
2. PROPOSED SEDIMENT SAMPLING LOCATION NOT SAMPLED BECAUSE MANHOLE GRATE COULD NOT BE REMOVED OR PIPE WAS CAPPED.
3. PROPOSED SEDIMENT SAMPLING LOCATION NOT SAMPLED DUE TO PRESENCE OF FECAL MATTER OR OTHER SANITARY WASTES.
4. PROPOSED SEDIMENT SAMPLING LOCATION WAS NOT SAMPLED BECAUSE STRUCTURES WERE NOT VISIBLE (COVERED WITH ASPHALT/CONCRETE) OR NO LONGER EXISTED.
5. PROPOSED SEDIMENT SAMPLING LOCATION NOT SAMPLED BECAUSE IT IS NO LONGER ACCESSIBLE (BENEATH TANK, BACKFILL, ETC.)
6. PROPOSED SEDIMENT SAMPLING LOCATION NOT SAMPLED. GRATE NOT REMOVED DUE TO LARGE ICE BUILD-UP, CHEMICAL (SULFUR) ODOR, AND SOUND OF LARGE FLOW OF WATER

REFERENCES: AUSTIN COMPANY, 1966; HORNER AND SHIFRIN, 1973; HORNER AND SHIFRIN, 1971; HORNER AND SHIFRIN, 1970; HORNER AND SHIFRIN, 1965; MALLINCKRODT CHEMICAL WORKS, 1971; MALLINCKRODT CHEMICAL WORKS, 1967a; MALLINCKRODT CHEMICAL WORKS, 1967b; MALLINCKRODT INC., 1992; MALLINCKRODT INC., 1991; MALLINCKRODT INC., 1989a; MALLINCKRODT INC., 1989b; MALLINCKRODT INC., 1985a; MALLINCKRODT INC., 1985b; MALLINCKRODT INC., 1983; MSD, 2000; MSD, 1965; USACE, 1994; USACE, 1990; WESTLAKE CONSTRUCTION COMPANY, 1973; WARREN AND VAN PRAAG, INC. 1980

U:\CAD\SLDS\Dwgs\Inaccessible Areas\RI Report\SLDSSewerSoilSamp_Overview.dwg

**LEGEND:**

- MED/AEC PRODUCTION AND SUPPORT AREAS
- COMMERCIAL PRODUCTION AND SUPPORT AREAS
- BOTH MED/AEC AND COMMERCIAL AREAS
- M — SEWER LINE SERVING MED/AEC OPERATIONS
- C — SEWER LINE SERVING COMMERCIAL OPERATIONS
- M/C — SEWER LINE SERVING MED/AEC AND COMMERCIAL OPERATIONS
- SEWER LINE
- SEWER LINE FLOW DIRECTION
- MANHOLE
- SURFACE DRAIN
- CURB DRAIN
- GATEWELL
- SUMP
- DOWNSPOUT
- BLOCKED
- PLG PLUGGED
- EXISTING BUILDING
- HISTORICAL BUILDING FOOTPRINT
- PORTIONS OF SEWERS THAT HAVE BEEN REMEDIATED UNDER 1998 ROD.
- PORTIONS OF SEWERS THAT WILL BE REMEDIATED UNDER 1998 ROD.
- SEDIMENT SAMPLING LOCATIONS $SOR_N<1$
- SOIL BORING LOCATIONS $SOR_N<1$
- SOIL BORING LOCATIONS $SOR_N \geq 1$
- SOIL BORING LOCATIONS As>60 mg/kg
- SOIL BORING LOCATIONS Cd>17 mg/kg
- SOIL BORING LOCATIONS Pb>800 mg/kg
- SEDIMENT SAMPLING LOCATIONS As>1.6 mg/kg
- SEDIMENT SAMPLING LOCATIONS Cd>17 mg/kg
- SOIL SAMPLE LOCATIONS FROM SEWER EXCAVATION (2005–2006) $SOR_N \geq 1$
- PROPOSED SEDIMENT SAMPLING LOCATION OR SOIL BORING LOCATION NOT SAMPLED
- SOIL SAMPLE LOCATIONS FOR DESTREHAN STREET PDI (2010) $SOR_N<1$

0 60 120 240
SCALE: 1" = 120'

FUSRAP

Sewers
St. Louis Downtown Site
St. Louis, Missouri

| DRAWN BY: | REV. NO./DATE: |
|---|---|
| F. Bauer | 10/26/2011 |

Figure H-8. Sediment and Soil Sampling Locations for Sewers at the SLDS

# APPENDIX I

## Background Sewer Sediment Evaluation

## (On the CD-ROM on the Back Cover of this Report)

# APPENDIX J

## Data: Radiological and Metals Analytical Data Summaries for Sewers and Inaccessible Soil Associated with Sewers by Plant or Property Area

## (On the CD-ROM on the Back Cover of this Report)

# APPENDIX K

## Baseline Risk Assessment

# TABLE OF CONTENTS

## LIST OF FIGURES



## LIST OF TABLES

## LIST OF TABLES (Continued)

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# K1.0 BASELINE RISK ASSESSMENT

This ISOU BRA was conducted to estimate and characterize baseline dose and risks to the most likely human receptors identified at the SLDS properties as a result of potential current and future exposures to radiological and metal COPCs identified in ISOU media (Section 4.0). As previously discussed in Section 1.1.1, radiological and metal COPCs were determined to be present in ISOU media, as a result of former MED/AEC operations, are considered for further actions. Only metal COPCs located in the uranium-ore processing area, as identified in Figure 1-2, or that are associated with the sewers are considered for further actions. Additionally, the BRA summarizes the results and recommendations of the 1993 environmental assessment of biota and presents a discussion of evaluation methods applied during the 1993 BRA (DOE 1993) versus current methods. The results of a site walk-over that was conducted on September 10, 2010, and subsequent completion of USEPA's Ecological Checklist also are presented to compare and contrast with conditions reported in 1993. Thus, the BRA consists of two main components: the HHRA (Section K2.0) and the Ecological Assessment (Section K3.0). Section K4.0 provides a high-level summary of both the HHRA and Ecological Assessment.

Supporting analytical data, information, and calculations to this BRA are provided in the following appendices:

- Appendix E – Data: Radiological and Metals Analytical Data Summaries for Inaccessible Soil by Property;
- Appendix F – Data: Radiological Building Survey Results by Property and Building;
- Appendix J – Data: Radiological and Metals Analytical Data Summaries for Sewers and Inaccessible Soil Associated with Sewers by Plant or Property Area;
- Appendix L – Radiological and Metals Analytical Data Summaries and Figures for Accessible Soil by Property;
- Appendix M – Exposure Point Concentration Calculations for Radiological COPCs;
- Appendix N – Exposure Point Concentration Calculations for Metal COPCs;
- Appendix O – RESRAD Model Outputs: Radiological Dose and Risk Calculations for Inaccessible Soil and Sewer Soil Borehole Locations;
- Appendix P – RESRAD-BUILD Model Outputs: Radiological Dose and Risk Calculations for Exterior Building Surfaces;
- Appendix Q – Dose and Risk Calculations for Exposures to Metal COPCs in Inaccessible Soil, Sewer Sediment, and Soil Adjacent to Sewer Lines; and
- Appendix R – Ecological Checklist for the SLDS ISOU.

# K2.0 HUMAN HEALTH RISK ASSESSMENT

The scope of the HHRA includes all media not covered by the 1998 ROD (USACE 1998a), as previously described in detail in Section 1.1.2, that may have become contaminated as a result of the deposition or migration of MED/AEC-related contaminated media, and that exceed the health-based screening levels presented in Section 4.0. This HHRA was prepared based on analytical data acquired primarily during the ISOU RI, as well as select data from previous USACE investigations at the SLDS. This HHRA identifies risk driver COCs, properties/areas, and structures exceeding benchmark dose and risk criteria to be retained for further actions. More specifically, the purpose of the HHRA is to identify those ISOU media and properties/areas that exhibit dose or cancer risk that exceed the target dose value of 25 mrem/yr, USEPA's target CR of 1.0E-05, or USEPA's target non-cancer HI of 1.0. Discussions of the target CR and HI are provided in Section K2.5. Although USEPA's (1990) NCP identifies 1.0E-06 as the point of departure for all risk evaluations, the CR of 1.0E-05 represents the mid-point of USEPA's acceptable target CR range of 1.0E-06 to 1.0E-04. Application of the target CR of 1.0E-05 is consistent with the current and expected future land use of the SLDS as a heavily industrial area in an urban setting, and facilitates the identification of those SLDS properties that should be retained for further evaluation in the FS. Risk-driver COPCs that result in target dose or risk criteria being exceeded are identified as COCs for the FS.

Properties are evaluated based on dose and risk associated with ISOU media; however, properties for which target dose or risk criteria are exceeded for inaccessible soil are carried forward into property-wide evaluations that include inaccessible and accessible soil data. In order to facilitate this evaluation, it is assumed that all inaccessible soil at each property has become accessible, so that inaccessible and accessible soil can be assessed under one consistent set of (accessible) exposure scenarios. This HHRA process for the ISOU is described in later sections of the HHRA, and is also presented schematically, within the overall framework of CERCLA, in Figure K-1. Based on application of this evaluation process, the results of the HHRA have determined that of the 16 SLDS properties evaluated for any of the ISOU media (i.e., those properties retained for the HHRA based on the screening level exceedances presented in Section 4.0), 13 properties are being retained for further evaluation in the FS.

## K2.1 INTRODUCTION

The SLDS is comprised of numerous Mallinckrodt plant areas and VPs. Each property quantitatively evaluated in this HHRA, along with specific buildings and locations within each property, is considered an exposure area. The ISOU media being evaluated at each property consist of the following, for which property/area-specific receptor scenarios have been developed:

- Soil that is inaccessible due to the presence of buildings and other permanent structures, including the subsoil within the footprint of a structure of which remediation would reasonably be expected to affect the stability of the structure.
- Soil located under active RRs, including the supporting soil in the associated ROW.
- Soil located under roadways, including the supporting soil in the associated ROW.
- Soil on the exteriors and interiors of buildings and permanent structures (e.g., tanks, bridges, sheds, loading docks, utility poles, traffic signals, piping, rail tracks, and equipment boxes).

- Sewers (e.g., structures and interior sediment) not directly encountered within an excavation area during the remedial action conducted under the 1998 ROD.
- Soil adjacent to sewers located beneath buildings, permanent structures, RRs, and/or roads.

This HHRA presents human health dose and risk information specific to each receptor scenario, along with an overall analysis of uncertainty, as an aid in the decision-making process. Characterizing baseline human health dose and risks at each property provides stakeholders with information that will be helpful to make decisions to protect human health and the environment, if necessary. The expected end-use of these dose and risk estimates is the recommendation of properties and areas for further evaluation in the FS.

Both current and expected future land uses at the SLDS have been considered in developing exposure scenarios for each property/area associated with past MED/AEC operations, as well as for those areas that have been potentially impacted by those operations. Given the current land use and the long history of the SLDS as a heavily industrial and urban setting for over 100 years, the land use will remain as such for the foreseeable future; therefore, evaluations in this BRA focus on exposure scenarios consistent with this land use.

Radiological dose and CRs are estimated using DOE's RESRAD and RESRAD-Build computer codes for soil/sediment and structural surfaces, respectively. Human health risks are characterized herein for metal COPCs as estimates of excess lifetime CRs for carcinogenic effects and non-carcinogenic HIs for systemic effects. Carcinogenic risks and non-carcinogenic hazards are estimated for metal exposures using mathematical algorithms presented in various USEPA risk assessment guidance documents. This HHRA has been conducted based on the methodology presented in Appendix A of the RI WP (USACE 2009a) and has applied methods from the following USEPA guidance documents:

- *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual: Part A* (USEPA 1989a);
- *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual: Part B, Development of Risk-Based Preliminary Remediation Goals* (USEPA 1991a);
- *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual: Part E, Supplemental Guidance for Dermal Risk Assessment* (USEPA 2004);
- *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual: Part F, Supplemental Guidance for Inhalation Risk Assessment* (USEPA 2009b);
- *Exposure Factors Handbook, Vol. 1: General Factors* (USEPA 1997a);
- *Child-Specific Exposure Factors Handbook* (USEPA 2008);
- *Guidance for Data Usability in Risk Assessment (Part A)* (USEPA 1992b);
- *Regional Screening Levels* Tables [USEPA 2011a (and Updates)];
- *Guidance for the Data Quality Objective Process* (USEPA 2000);
- *Soil Screening Guidance: User's Guide* (USEPA 1996a);
- *Radiation Exposure and Risk Assessment Manual* (USEPA 1996b);
- *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA 2002a); and
- *Supplemental Guidance for Developing Soil Screening Levels at Superfund Sites* (USEPA 2002b).

For all ISOU media, the HHRA itself is generally comprised of several significant steps (identification of COPCs, exposure assessment toxicity assessment, and dose and risk characterization). Thus, the main components of this HHRA are as follows:

- **Section K2.2 – Summary of Data Evaluation and Identification of COPCs:** Briefly summarizes the validity of data acquired during the RI for use in the risk assessment and the identification of COPCs, buildings, and properties, being evaluated in this HHRA, as previously presented in Sections 3.0 and 4.0.
- **Section K2.3 – Exposure Assessment:** Presents the land use and potentially exposed populations, CSM, methodology for estimating EPCs, pathway intake equations for metal exposures, and input values for radiological and metal exposure parameters, including overviews of the RESRAD and RESRAD-Build computer models used for evaluating radiological exposures to soil/sediment and structures, respectively.
- **Section K2.4 – Toxicity Assessment:** Describes the approach used to evaluate carcinogenic effects from radiological and metal exposures in terms of CRs and non-carcinogenic effects from metal exposures in terms of hazards, as well as quantitative indices of toxicity used for estimating both potential risks and hazards.
- **Section K2.5 – Dose and Risk Characterization:** Describes the methodology used for the estimation of doses and CRs for radiological exposures and CRs and non-carcinogenic HIs for exposures to metals by integrating the results of the exposure and toxicity assessments. Radionuclides and metals contributing predominantly to doses, CRs, and HIs (i.e., as risk drivers) exceeding target criteria will be identified as COCs to be considered for future actions.
- **Section K2.6 – Uncertainties Analysis:** Discusses sources and implications of uncertainty in the risk assessment process, including ISOU-specific factors contributing to the overall uncertainty of the HHRA results.

All figures and tables for Appendix K that are called out in text are presented at the end of the text. Radiological and metals information for the same scenarios are presented in separate tables. In most cases, table numbers with an "A" suffix (e.g., Table K-2A) present information pertaining to radiological evaluations, and table numbers with a "B" suffix (e.g., Table K-2B) present information pertaining to metals evaluations.

## K2.2 SUMMARY OF DATA EVALUATION AND IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN

All ISOU RI data underwent data validation to determine its usability for risk assessment purposes. Data were qualified accordingly with regard to usability. All RI data were found to be usable and are incorporated into the risk assessment. A detailed evaluation of the data is presented in the QCSR (see Appendix B).

COPCs, buildings, and properties/areas being retained for radiological and/or metals dose/risk evaluations were identified in Section 4.0 through comparisons with screening levels that also included calculations of radiological $SOR_N$ values based on site, background, and screening level concentrations. Both radiological and metals screening values used for comparisons with inaccessible soil and sediment levels are presented in Table 4-1. Appendix E presents tables showing the identification of radiological and metal COPCs through calculations of $SOR_N$ values and data comparisons with screening levels, respectively. The tables in Appendix E also present summary statistics for each dataset.

Radiological PCOCs identified for inaccessible soil, soil on the surfaces of buildings/structures, sewer sediment, and soil adjacent to sewers in the RI WP (USACE 2009a), and presented in Table 4-1, were retained as radiological COPCs for this HHRA. These include Ac-227, Pa-231, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-235, and U-238. Properties where at least one inaccessible soil sample was collected that exhibited a $SOR_N$ >1.0 were retained for radiological dose and risk evaluations in this HHRA. These properties are presented in Table 4-8. $SOR_N$ values were calculated for each sediment sample collected from 23 sewer locations and were found to be <1.0; therefore, none of the sewer sediment locations were retained for evaluation in the radiological dose and risk assessment.

Ore-related metals were identified as COPCs in inaccessible soil for each property/area located within the uranium-ore processing area presented on Figure 1-2, as well as within each soil borehole adjacent to a sewer line, based on exceedances of risk-based screening levels. Metals in sewer line sediments and in soil adjacent to sewer lines that serviced plants and buildings within the uranium ore processing area were evaluated as COPCs, even if the sampling locations were outside of the uranium-ore processing area.

The following items summarize radiological and metal COPCs identified for each type of ISOU medium:

- Radionuclides and/or arsenic were identified as COPCs in soil that is inaccessible due to the presence of buildings and other permanent structures, including the subsoil within the footprint of a structure of which remediation would reasonably be expected to affect the stability of the structure. The COPCs identified for this type of inaccessible soil are presented below by property:
  - Plant 1 – radionuclides,
  - Plant 2 – radionuclides,
  - Plant 6 – radionuclides,
  - St. Louis City Property (DT-2) – radionuclides,
  - Gunther Salt (DT-4) North – radionuclides,
  - Heintz Steel (DT-6) – radionuclides,
  - PSC Metals, Inc. (DT-8) – radionuclides, and
  - Thomas and Proetz Lumber Company (DT-10) – arsenic.
- Radionuclides, arsenic, and/or cadmium were identified as COPCs in soil located under active RRs, including the supporting soil in the associated ROW as summarized below:
  - Norfolk Southern RR (DT-3) – radionuclides,
  - Terminal RR (DT-9) Main Tracks – radionuclides and cadmium,
  - Terminal RR (DT-9) Rail Yard – radionuclides, and
  - Terminal RR Soil Spoils Area – radionuclides, and
  - BNSF RR (DT-12) – radionuclides and arsenic.
- Radionuclides were identified as COPCs in soil located under the roadways listed below, which include the supporting soil in the associated ROWs. Roadways are defined as the public and private streets. It should be noted that this type of inaccessible soil does not include soil beneath driveways, parking lots, or other paved surfaces that were addressed as accessible soil areas.
  - Hall Street (West of Plant 6),
  - North Second Street (West of Plant 1),
  - Mallinckrodt Street (North of Plant 2),

  - Destrehan Street (West of Hall Street), and
  - Angelrodt Street (South of Plant 7S).

- Radionuclides were identified as COPCs in soil on the exteriors of the following buildings and permanent structures:
  - Building 25 at Plant 1,
  - Wood Storage Building at Thomas and Proetz Lumber Company (DT-10), and
  - horizontal beam between L-shaped building and brick warehouse at Cotto-Waxo Company (DT-14).

- Radionuclides, arsenic, cadmium and lead were identified as COPCs in soil adjacent to sewers in the following properties that were not directly encountered within an excavation area during the remedial action conducted under the 1998 ROD:
  - Plant 1 – radionuclides, arsenic, cadmium, and lead,
  - Plant 2 – lead,
  - Plant 6 – radionuclides (sewer line) and lead,
  - St. Louis City Property (DT-2) – radionuclides,
  - Plant 7N/BNSF RR – radionuclides (sewer line excavation) and cadmium.

Additionally, metal COPCs were identified in sediment samples collected from inside of various sewer manholes at the following properties:

- Plant 1 – arsenic and cadmium,
- Plant 2 – arsenic,
- Plant 6 – arsenic, and
- Sewer Line Near McKinley Bridge (DT-11) – arsenic

## K2.3 EXPOSURE ASSESSMENT

To evaluate potential risks to human health at a given site, exposure must first be evaluated and quantified. For radiological COPCs, exposure occurs when there is physical contact between a human and a radionuclide COPC in the environment or between a human and the external radiation emitted from a radionuclide. For metals COPCs, exposure occurs when there is contact between a human and a metal COPC in the environment. The exposure assessment is performed to estimate the magnitude, frequency, duration, and route of the potential exposure of the human receptors to COPCs present in ISOU media at the SLDS and consists of the following elements:

- description of the site setting (previously discussed in Section 3.0);
- identification of the current and future land use and potentially exposed people (receptors);
- pathways through which people may be exposed;
- calculation of EPCs of COPCs; and
- presentations of intake equations including exposure factors that will be used to estimate intake for each COPC, exposure pathway, and receptor.

A CSM for the ISOU was presented and discussed in Section 5.0 and Figure 5-1. The CSM presented complete and incomplete exposure pathways identified for ISOU media and receptors under current configurations. This included contaminant sources, release/transport mechanisms, exposure media, and exposure routes that comprise the exposure pathways. Under current configurations (i.e., per Figure 5-1), the only potential exposure route for inaccessible soil contaminants beneath consolidated ground cover (e.g., buildings and pavement) is external radiation. For inaccessible soil beneath unconsolidated cover or no cover, ingestion, dermal contact, and external radiation could occur. In this HHRA, it assumed that all inaccessible soil has become accessible and that no consolidated or unconsolidated ground cover exists. The absence of ground cover in the HHRA assumes direct contact exposures to soil can occur via ingestion, dermal contact, inhalation of dusts, and external radiation. Exposures to contaminated soil on building surfaces could occur via ingestion, inhalation and external radiation. Exposures to sediment inside of manholes and sewer lines could occur via ingestion and dermal contact. Finally, exposures to inaccessible soil adjacent to sewer lines can occur via ingestion, dermal contact, inhalation of dusts, and external radiation, following excavation.

Exposure scenarios are evaluated in this HHRA that are based on land use, identification of potentially exposed individuals, and human exposure routes. EPCs are also important in the evaluation of each scenario. Therefore, prior to discussing exposure scenarios in Section K2.3.2, the general methodology for calculating EPCs is presented in Section K2.3.1.

### K2.3.1 Quantification of Exposure Point Concentrations

Sections K2.3.1.1 and K2.3.1.2 discuss the general methodologies for calculating property/receptor-specific EPCs for the following media: 1) inaccessible soil, sewer sediment, and soil adjacent to sewer lines, and 2) soil on building surfaces, respectively. Table K-1 summarizes the property-specific receptor scenarios evaluated in the HHRA, for which EPCs were determined. The radiological EPCs are presented in Tables K-2A, K-3A, K-4A, K-5, K-6B, K-8A, and K-15A. Likewise, EPCs for metal COPCs are presented in Tables K-2B, K-3B, K-4B, K-7, K-8B, and K-15B. Data inputs and calculation outputs for radiological and metal EPCs are presented in Appendices M and N, respectively. All locations and sample IDs associated with each set of EPC calculations are also presented in Appendices M and N.

#### *K2.3.1.1 Exposure Point Concentrations for Inaccessible Soil, Sewer Sediment, and Soil Adjacent to Sewer Lines*

To calculate a cancer risk for radiological and metal COPCs or a non-cancer hazard for metal COPCs, an estimate must be made of the COPC concentration in the environmental medium to which an individual may be exposed. To quantify exposure to each receptor, an EPC, or the estimate of the constituent concentration a receptor is likely to come in contact with over the duration of exposure, is calculated. The EPC is used to estimate the dose and intake for each radiological and metal COPC, respectively, by individual receptors via all pathways and media identified in the CSM. An EPC was calculated for each COPC identified within each ISOU medium and is specific to the property/location-receptor scenario for which it was applied. If no COPCs were identified, then no EPC was calculated because the scenario does not require quantitative dose/risk evaluations. Generally, depending on the property or area/location, and based on the identification of COPCs in Section 4.0, EPCs were determined for the following ISOU media (radiological/metal EPCs indicated): inaccessible soil (radiological and metal EPCs), building surfaces (radiological EPCs), sewer sediment (metal EPCs), and soil adjacent to sewer lines (radiological and metal EPCs).

In accordance with USEPA (2002a) guidance, the EPC should be the estimate of the average concentration measured over the area to which an individual receptor would be exposed for the duration of the exposure. Because of the uncertainty associated with estimating the true average concentration at a site, USEPA recommends that the lesser of the 95% UCL or the maximum detected concentration be used as the appropriate estimate of the average site concentration for a reasonable maximum exposure scenario. Essentially, the 95% UCL is a conservative, upper-bound estimate of the mean concentration and, by using the 95% UCL, the probability of underestimating the true mean is less than 5%. The 95% UCL also accounts for uncertainties resulting from limited sampling (Gilbert 1987). Under certain situations (e.g., small sample sizes), the 95% UCL may be greater than the maximum detected concentration. For this reason, USEPA recommends the selection of the lower of the two values as the appropriate EPC, which was applied for both radiological and metal COPCs. However, for radiological COPCs, an extra step was applied toward calculation of the EPC that involved subtraction of the site-specific mean background concentration from the lesser of the 95% UCL and the maximum detected concentration. The radiological EPC used for calculating dose and risk was the difference obtained after subtraction of background. Contrary to the EPC methodology for radionuclides, and for consistency with USEPA (1989a) risk assessment guidance, the background concentration was not subtracted from the lesser of the 95% UCL and maximum detected concentration to determine the EPC for a metal COPC.

The 95% UCL was calculated in accordance with *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA 2002a). Before calculating the 95% UCL, the distribution of the dataset was determined (e.g., normal, lognormal, non-parametric). Subsequently, the 95% UCL was calculated based on the distribution determined for the dataset. To simplify this calculation process, USEPA's ProUCL software was used to determine both data distributions and the corresponding 95% UCLs for each set of data.

For this HHRA, the greater of the two results obtained for a COPC from analysis of a field duplicate pair was used in the calculation of EPCs to avoid the "double-counting" of data from any one soil sampling location/depth. This approach was still applied in the event that a split sample was collected along with the field duplicate pair, and the split sample result was reported to be the maximum result. Therefore, split samples were not included in datasets used to calculate EPCs. Split sample data are used only for QA purposes, the results of which are reported and discussed in the QCSR (Appendix B), because the field duplicate pair and split sample are analyzed at different laboratories. For risk assessment purposes, it is preferred that data generated from one laboratory (i.e., the primary laboratory) be used to calculate EPCs, unless the dataset must also include historical data generated by a different laboratory. Using RI data generated from only the primary laboratory eliminates uncertainties that can result from inter-laboratory variability.

For non-detect metals results (i.e., qualified "U" or "UJ"), the 95% UCL cannot be estimated unless numerical values are assigned. For analytical results, USEPA's (1989a) RAGS Part A recommends that SQL/2, or one-half the MDL, be used as a proxy value for non-detect results. For the purposes of calculating 95% UCLs, as well as descriptive statistics (i.e., mean, standard deviation, etc.) for metals evaluated in this HHRA, non-detect results were replaced with proxy values equivalent to SQL/2, prior to application of ProUCL.

#### *K2.3.1.2 Radiological Exposure Point Concentrations for Soil on Building Surfaces*

According to the CSM, the SLDS plant/VP employee is being evaluated for exposures to radiological COPCs on building surfaces. All radiological survey measurements for buildings were analyzed as gross alpha activities. If at least one sample result for building surfaces exceeded the gross alpha DCGL, then the gross alpha results (either all exterior or all interior) from the survey were inserted into the USEPA-designed software, ProUCL, to calculate the 95%

UCL. The lesser of the ProUCL-recommended 95% UCL and the maximum gross alpha measurement was then converted from dpm/100 $cm^2$ to pCi/$m^2$ as follows:

$$gross\ alpha\ \left({}^{pCi}/_{m^2}\right) = gross\ alpha\ \left({}^{dpm}/_{100\ cm^2}\right) \times 10{,}000\ {}^{cm^2}/_{m^2} \times \left({}^{1\ pCi}/_{2.22\ dpm}\right)$$

This conversion was conducted to adjust the gross alpha units into those units required for the RESRAD-Build parameter input.

SLDS-specific activity fractions were calculated as they were necessary to appropriately assign portions of the average gross alpha 95% UCL value into radionuclide-specific EPCs required for RESRAD-Build parameter inputs.

Activity fractions were calculated by dividing individual radionuclide soil concentration values by the sum of soil concentration values for all COCs. Soil concentration values used for this calculation were selected from Table 3.9 of the 1993 BRA (DOE 1993). Because survey instrumentation could not distinguish between individual radionuclide activities (e.g., instruments only provide a gross alpha value, etc.), it was assumed that any areas exceeding screening levels must have been contaminated from the surrounding contaminated soil at the SLDS and, therefore, would have the same activity fractions as the soil at the SLDS. Activity fractions are presented in Table K-6A.

Finally, individual radionuclide-specific EPCs were calculated by multiplying the gross alpha value (lesser of the 95% UCL and maximum gross alpha) by the radionuclide-specific activity fraction. Exterior surfaces at five buildings exceeded the gross alpha DCGL; however, two buildings were removed from further evaluation due to the exceedances being due to NORM present in clay brick caps. Therefore, exterior surface EPCs were calculated for each radiological COPC and are presented in Table 6-5B for each of three buildings being quantitatively evaluated for dose and risk. None of the interior building surfaces surveyed exceeded the gross alpha screening level.

### K2.3.2 Identification of Land Use and Potential Exposure Scenarios

The SLDS is located in a heavily urban setting. Current land use is predominantly industrial and commercial and is expected to remain as such for the foreseeable future. This HHRA focuses on those receptors that are likely to be exposed to contaminated inaccessible soil or sediment under future land use scenarios that assume the temporary loss of existing ground cover (e.g., during construction projects) and institutional controls. This HHRA does not assume that the properties are redeveloped for land uses other than industrial/commercial use. This approach ensures that a reasonable maximum risk will be characterized under existing land use patterns and that all potential receptors will be adequately protected. The future land use of the SLDS is expected to be heavily industrial within an urban setting. The following receptors have been identified as the basis for the scenarios:

- *Current and Future Industrial Worker* – The industrial worker is a SLDS plant/VP employee assumed to work indoors 1,600 hours per year (200 days per year) and also performs light excavation/construction work outdoors for an additional 400 hours per year (50 days per year). An additional 125 hours is assumed for the indoor time fraction to account of the possibilities of early arrivals to work, having lunch on-site, and late departures. Industrial workers are therefore, individuals working mainly indoors with some outdoor activities at the plants, industrial/commercial VPs, RRs, and roadways.

This group includes site workers performing daily job activities specific to the plant/VP at which they are employed (e.g., working at various plant processes and industrial/commercial work activities at the plants and VPs, office workers, and building maintenance employees). Industrial worker exposures are assumed to occur property-wide, and not limited to any particular area of the property at which they are employed. Because of the exposure frequency, coupled with the assumed exposure duration (25 years) at the property, the industrial worker in this HHRA is assumed to be the maximally exposed individual at the ISOU. Therefore, this receptor is evaluated at all ISOU properties where screening level exceedances have been observed.

- Future SLDS Construction Workers – The construction worker is assumed to be a contractor (i.e., not a SLDS plant/VP employee) who performs one-time, deep excavation and construction activities at the ISOU, over a period of 90 days. This group also includes individuals doing construction work along any portion of the RR VPs and roadways within the ISOU study areas. Construction workers were not evaluated for exposures at plant properties and industrial/commercial VPs because the industrial worker scenario assumes a time fraction for outdoor construction activities and is generally more conservative than the construction worker scenario.
- Current and Future Utility Workers – The utility worker is assumed to work in small areas, performing utility work and is assumed to be exposed to areas of elevated concentrations at any of the plant properties, industrial/commercial VPs, RRs, and roadways. In a manner consistent with the 1998 ROD, a utility worker is assumed to perform one-time work (e.g., on utilities) within deep excavations in those areas, for a short time duration (80 hours or ten 8-hour days). Therefore, the utility worker scenario is used to evaluate elevated measurement areas for each of the properties with screening level exceedances.
- Current and Future SLDS Sewer Maintenance Workers – Sewer Maintenance Workers are assumed to be individuals performing infrequent work inside of sewers and manholes approximately one day per year over a 25-year duration.
- Current and Future St. Louis City Property Recreational Users – Recreational users are assumed to be primarily adolescents (ages 10 to 18 years old) who use the St. Louis Riverfront Trail along the St. Louis City Property (DT-2) levee for walking, jogging, and biking. It is further assumed that these individuals spend approximately 75 hours per year (i.e., one hour per day for 75 days), for nine years, engaged in these activities at the St. Louis Riverfront Trail.

The above information was used to develop receptor scenarios for evaluating potential human health dose and risk that could be associated with each of the ISOU media, at each property. The following subsections (K2.3.2.1 through K2.3.2.5) summarize the manner in which EPCs were derived and receptor scenarios were evaluated for all of types of inaccessible soil and sewer sediment.

#### *K2.3.2.1 Inaccessible Soil beneath Buildings, Structures, Railroads, and Roadways*

For each property, the evaluation of inaccessible soil beneath building, permanent structures, RRs and roadways includes all inaccessible soil areas. However, although this evaluation determines the dose/risk status of all inaccessible soil areas for a property, property-wide dose/risk status of all soil must also include accessible soil. Therefore, this HHRA applies a two-tiered approach of not only assessing inaccessible soil dose and risk (i.e., as the first tier), but of property-wide soil dose and risk that is inclusive of both inaccessible and accessible soil (i.e., as the second tier). In order to facilitate this evaluation, it is assumed that all inaccessible soil at each property has become accessible, so that inaccessible and accessible soil can be assessed under one consistent set of (accessible) exposure scenarios. Because the industrial worker is the maximally exposed receptor identified for the ISOU, this receptor scenario is evaluated under the two-tiered process, in order to assess overall property dose and risk. Additionally, a recreational user at the St. Louis City Property (DT-2) is evaluated using the two-tiered process as a conservative measure to determine potential property-wide doses and risks associated mainly with users of the St. Louis Riverfront Trail. Finally, a construction worker at the RR properties and roadways was also evaluated along with the industrial worker, but only for inaccessible soil exposures (i.e., not evaluated as under the Tier 2 process). This is because the determination of properties to be retained for further evaluation in the FS will be driven primarily by the results of the evaluation of the limiting receptor (i.e., the industrial worker). The construction worker scenario (assuming one-time exposures lasting 90 days) was applied to the RRs and roadways as a more realistic alternative to the industrial worker, for which EPCs were calculated based on all RI data. The two-tiered process for the industrial worker and the recreational user is summarized below.

***Tier 1 Evaluation – Evaluation of All Inaccessible Soil Areas at Property***

As shown in Figure K-1, and following identification of COPCs, EPCs at each of the plant properties, industrial/commercial VPs, RR properties, and roadways are first calculated for industrial worker evaluations that include data for all inaccessible soil areas (combined), within each property. It should be noted that the area of elevated measurements located along the western boundary of Plant 6, adjacent to Hall Street, were included in the calculations of EPCs for industrial workers at both Plant 6 and Hall Street. For the St. Louis City Property (DT-2), EPCs were calculated for the industrial worker and a recreational user. The inaccessible soil EPCs calculated for the industrial worker at the RRs and roadways were also used for evaluating construction workers. The EPCs for the inaccessible soil areas were then applied to the three receptor exposure scenarios below to determine dose and risk, as presented below. Tables presenting the EPCs associated with each scenario are presented in parentheses.

*Industrial Worker – All Plant Properties, Industrial/Commercial VPs, Railroad VPs and Roadways (EPC Tables K-2A, K-2B, and K-3A)*

- incidental ingestion of inaccessible soil,
- dermal contact with inaccessible soil,
- external gamma exposures from inaccessible soil, and
- inhalation of particulate dust emissions from inaccessible contaminated soil.

*Construction Worker – Railroad VPs and Roadways (EPC Tables K-3A and K-3B)*

- incidental ingestion of inaccessible soil,
- dermal contact with inaccessible soil,
- external gamma exposures from inaccessible soil, and
- inhalation of particulate dust emissions from inaccessible contaminated soil.

*Recreational User at the St. Louis City Property (DT-2) (EPC Table K-5)*

- external gamma exposures from inaccessible soil excavated from beneath the St. Louis City Property, and
- ingestion of inaccessible soil and inhalation of particulate dust emissions from inaccessible contaminated soil exposed from beneath the St. Louis City Property.

Table K-1 shows that the industrial worker scenario was applied to a total of 16 properties. Because the HHRA assumes that property-wide inaccessible soil has become accessible, the cover depth (i.e., the thickness of ground cover between the receptor and the top of the contaminated zone) is assumed to be zero meters for the industrial worker and construction worker. The exposure frequency used to evaluate industrial worker exposures to radiological COPCs (particularly as a result of external radiation) is equivalent to the total number of hours the employee spends on the property per year, which equates to approximately 265 days per year. However, exposures to metal COPCs in inaccessible soil via ingestion, dermal contact, and inhalation of dusts can only occur during the fraction of time spent outdoors, or 50 days per year. The entire exposure frequency assumed for the construction worker (90 days per year) is applied to the evaluations of inaccessible soil at the RR properties and roadways. For the recreational user at DT-2, the cover is comprised of levee material; therefore, a cover depth of one meter is assumed for the recreational user, based on the shallowest radiological screening level exceedance. Soil exposure assumptions for these receptors are presented for radiological and metals evaluations in Tables K-9 and K-11, respectively.

Based on the process outlined in Figure K-1, properties for which the inaccessible soil dose or risk estimated for the industrial worker exceed target criteria are carried through to the second tier of property-wide (combined inaccessible and accessible soil) evaluations involving the industrial worker scenario for plant properties and industrial/commercial VPs. As a conservative measure, the St. Louis City Property was retained for the Tier 2 evaluation of the recreational user, regardless of the Tier 1 dose and risk results relative to target criteria. As stated previously, the construction worker scenario was not carried forward into the second tier evaluation.

***Tier 2 Evaluation – Evaluation of All Inaccessible Soil and Accessible Soil Areas (Combined) at Property***

The second tier involves calculation of property-wide EPCs by combining and area-weighting the inaccessible soil EPC determined during Tier 1, with corresponding accessible soil EPCs that were either calculated during preparations of previous post-remediation/final status survey decision documents (e.g., PRARs and FSSEs) under the 1998 ROD, or that were calculated based on available FSS data. Generally, the Tier 2 EPC represents an area-weighted average of the total inaccessible soil area and the total accessible soil area of the property. Area sizes were generally calculated using the following methods:

- PRAR/FSSE Properties
  *Total Property Area – Total Accessible Soil Area = Total Inaccessible Soil Area*
- Propcrtics without a PRAR/FSSE
  *Total Property Area – Total Inaccessible Soil Area = Total Accessible Soil Area*

The area-weighted, property-wide EPCs were applied to the industrial worker exposure scenario for evaluations of all plant properties and VPs. The industrial worker scenario evaluated during the second tier evaluation (i.e., if Tier 1 dose and risk exceed target criteria), along with the recreational user scenario, are summarized below. The corresponding EPC tables are identified in parentheses; however, the area-weighted EPCs for both receptors are not presented until the risk characterization, after the estimation and summaries of the Tier 1 dose and risk results.

*Industrial Worker – All Plant Properties, Industrial/Commercial VPs, Railroad VPs and Roadways (EPC Tables K-15A and K-15B)*

- incidental ingestion of inaccessible soil,
- dermal contact with inaccessible soil,

- external gamma exposures from inaccessible soil, and
- inhalation of particulate dust emissions from inaccessible contaminated soil.

*Recreational User at the St. Louis City Property (DT-2) (EPC Table K-15A)*

- external gamma exposures from inaccessible soil excavated from beneath the St. Louis City Property, and
- ingestion of inaccessible soil and inhalation of particulate dust emissions from inaccessible contaminated soil exposed from beneath the St. Louis City Property.

As shown in Figure K-1, Tier 2 industrial worker and recreational user dose or risk exceedances result in the associated properties being retained for further evaluation in the FS.

*K2.3.2.2 Inaccessible Soil in Elevated Measurement Areas*

Properties are being evaluated in the HHRA because of the presence of radiological and metal concentrations in inaccessible soil above screening levels. Areas within properties that contain inaccessible soil concentrations that exceed screening levels are referred to as elevated measurement areas. These areas are being individually evaluated in this HHRA because it is possible that the Tier 1 and Tier 2 property-wide evaluations can show no dose or risk above target criteria, despite the presence of the elevated measurement areas. To evaluate these elevated measurement areas, it is assumed that a utility worker performs excavation and utility/construction work that is confined to the inaccessible soil within each elevated measurement area. An elevated measurement area was assumed to include elevated measurement sampling locations, along with immediately adjacent sampling locations where COPC concentrations are less than screening levels. Figure K-1 shows that the evaluations of the elevated measurement areas, using the utility worker scenario, are conducted independently of the tiered property-wide evaluations and the outcomes of those evaluations.

Consistent with the methodology and assumptions in the 1998 FS and 1998 ROD (USACE 1998b and 1998a, respectively), a utility worker is assumed to perform one-time work (e.g., on utilities) within deep excavations with those areas, for a short time duration (80 hours or 10, 8-hour days). An EPC has been calculated for each COPC based on the lesser of the 95% UCL and maximum detected concentration determined from all samples collected from within the area. Data were incorporated into the EPC calculations that included locations above screening levels, as well as nearest sample locations that exhibited no screening level exceedances. All EPCs estimated for radiological and metal COPCs in the inaccessible soil elevated measurement areas are presented in Tables K-4A and K-4B, respectively. The utility worker exposure scenario used to evaluate each of the elevated measurement areas across the ISOU is presented below:

- Utility Worker (All Plant Properties, Industrial/Commercial VPs, Railroad VPs and Roadways)
    - incidental ingestion of inaccessible soil,
    - dermal contact with inaccessible soil,
    - external gamma exposures from inaccessible soil, and
    - inhalation of particulate dust emissions from excavated inaccessible contaminated soil.

Exposure assumptions for this receptor are presented for radiological and metals evaluations in Tables K-9 and K-11, respectively. The utility worker at the RR properties and roadways would be comparable to a worker performing maintenance and repair work in those areas. Table K-1 shows 35 elevated measurement areas of inaccessible soil that are evaluated in the HHRA for utility worker exposures.

#### *K2.3.2.3 Soil of Surfaces of Buildings and Structures*

During maintenance or renovation/demolition activities involving existing structures, industrial workers could directly contact and become exposed to radiologically contaminated soil on building or structural surfaces. Based on the results of the building surveys, three buildings within the ISOU were found to have exterior surfaces that exhibited gross alpha activities exceeding the screening level of 3,900 dpm/100 $cm^2$. Potential exposures to these surfaces are assumed to occur throughout the duration of a typical renovation/construction project, which would likely be a once in a lifetime event for an industrial worker (SLDS/VP employee), lasting 30 days. For exposures during maintenance activities, the duration of exposures could be less than 30 days.

As previously discussed in greater detail in Section K2.3.1.2, EPCs for building and structural surfaces are calculated as the lesser of the 95% UCL and maximum gross alpha measurement, and converted to the unit of pCi/$m^2$. Individual radionuclide-specific EPCs were calculated by multiplying the gross alpha value (lesser of the 95% UCL and maximum gross alpha) by the radionuclide-specific activity fractions for SLDS soil (see Table K-6A), as obtained from the 1993 BRA (DOE 1993). Building/structural surface EPCs for this HHRA are presented in Table K-6B.

The HHRA scenario for evaluating future industrial worker exposures to radiological COPCs in soil on contaminated exterior building surfaces is summarized below:

- Industrial Worker (Exterior Building/Structural Surfaces)
  - incidental ingestion of soil on building/structural surfaces,
  - inhalation of particulate dust emissions from building/structural surfaces, and
  - external gamma exposures.

Radiological dose and risk for buildings/structures were calculated by entering the surface EPC and the exposure assumptions into the RESRAD-Build model. All exposure assumptions used as model inputs are presented in Table K-10.

#### *K2.3.2.4 Sediment in Sewer Lines*

As discussed previously in Section K2.2, only metal COPCs (arsenic and cadmium) were identified in sewer sediment. Because only one sample was collected from each location, EPCs are represented by the measured sample concentrations reported for each COPC at each location. All metal EPCs for sewer sediment are presented in Table K-7.

During infrequent maintenance work on the interiors of manholes and sewer lines (assumed to be one day per year over 25 years), the potential exists for ingestion and dermal exposures to metal COPCs in sediment. Maintenance worker inhalation exposures to sediments are not likely to occur via the generation of particulate emissions during work activities due to the high moisture content that is characteristic of sediment. The HHRA scenario for evaluating sewer maintenance worker exposures to metal COPCs in sewer sediment is summarized below:

- Sewer Maintenance Worker (Sediments in Sewer Lines)
  - incidental ingestion of contaminated sediment in sewers, and
  - dermal contact with contaminated sediment in sewers.

All exposure assumptions for this receptor are presented in Table K-11.

#### *K2.3.2.5 Soil Adjacent to Sewer Lines*

Radiological and/or metals COPCs (arsenic, cadmium, and lead) were identified at specific sampling locations adjacent to sewer lines (i.e., at six soil borehole locations and three areas of sewer excavations, which include nine sidewall soil samples), within the properties identified in Section K2.2; therefore, EPCs were determined for each borehole sampling location. Because two or three depth intervals were sampled per soil location, and because 95% UCLs cannot be determined for only two or three samples, the EPC for each soil location is represented by the maximum detected concentration at each location (minus background for radiological evaluations). All radiological and metal EPCs determined for inaccessible soil locations adjacent to sewer lines are presented in Tables K-8A and K-8B, respectively.

The exposure scenario used for evaluating soil adjacent to sewer lines assumes that direct contact with this medium can only occur to individuals when excavation is performed (e.g., during removal/replacement of sewer lines). During an excavation scenario, the sewer utility worker is assumed to be the most likely individual who could become exposed to small localized areas of inaccessible soil. Therefore, the HHRA scenario for evaluating sewer utility worker exposures to radiological and metal COPCs in soil adjacent to sewer lines is summarized below:

- Sewer Utility Worker (Inaccessible Soil Adjacent to Sewer Lines)
  - incidental ingestion of inaccessible soil,
  - dermal contact with inaccessible soil,
  - external gamma exposures from inaccessible soil, and
  - inhalation of particulate dust emissions from excavated inaccessible contaminated soil.

Assumptions and RESRAD model inputs used for evaluating sewer utility worker exposures to radiological and metal COPCs in inaccessible soil adjacent to sewer lines are presented in Tables K-9 and K-11, respectively.

### K2.3.3 Methodology for Quantifying Dose

The magnitude of human exposure to contaminants in environmental media is usually described in terms of a dose. Radiological dose is a measure of the radiation absorbed by the body based on radionuclide concentrations and different intake pathways (ingestion, inhalation, and external radiation) and is expressed as mrem/yr. Chemical dose (also referred to as "intake") is a measure of exposure expressed as the concentration of a constituent that has come in contact (ingestion, dermal contact, and inhalation) with a receptor per unit body weight per unit of time (mg/kg-day). Sections K2.3.3.1 and K2.3.3.2 describe the methodologies used for calculating doses for radiological and metal COPCs, respectively.

#### *K2.3.3.1 Estimation of Radiological Dose and Risk*

RESRAD was used for the dose and risk assessments to calculate dose and risk to potential ISOU receptors from exposures to soil and sediment. RESRAD-Build was used for determining risk and dose from exposures to contaminated building surfaces. RESRAD and RESRAD-Build are computer codes developed at Argonne National Laboratory for DOE to determine site-specific residual radiation guidelines and dose to on-site receptors 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, including the following examples:

- USEPA used RESRAD in its "Reassessment of Radium and Thorium Soil Concentrations and Annual Dose Rates," which demonstrated the protectiveness of

Uranium Mill Tailings Radiation Control Act soil criteria, and in its rulemaking for cleanup of sites contaminated with radioactivity.

- Seven U.S. Cabinet-level agencies including USEPA, DOE, NRC, and the U.S. Department of Defense, functioning as the Interagency Steering Committee on Radiation Standards, formally accepted RESRAD-BIOTA.
- USEPA was also a signatory to the 1998 ROD (USACE 1998a), which incorporated RESRAD evaluations, and is a participant in many other CERCLA actions utilizing RESRAD.

In accordance with Title 40 *CFR* Part 192, Subpart A, control of residual radioactive materials from inactive uranium processing sites shall be designed to be effective for up to 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. Therefore, for inaccessible soils, radiological risk in this HHRA, as well as dose, has been assessed over a 1,000-year period. Tables K-9 and K-10 present values assigned to all relevant non-default RESRAD and RESRAD-Build input parameters, respectively.

#### *K2.3.3.2 Pathway-specific Dose Calculations for Exposures to Metal Contaminants of Potential Concern*

Chemical dose is the amount of chemical that comes into contact with an exchange surface [e.g., skin, lungs, and gastrointestinal (GI) tract] and is absorbed into the body, averaged over the duration of exposure (for non-carcinogens) or a lifetime (for carcinogens). The magnitude of the dose is also dependent on the body weight of the receptor. All doses determined for metal COPCs were based on chronic exposures (as opposed to subchronic exposures) or exposures that occur on a daily basis for at least 90 days. For ingestion exposures to contaminants in any environmental medium, dose is referred to as the chronic daily intake (CDI) (USEPA 1989a). For dermal exposures to contaminants, dose is referred to as the dermally absorbed dose (DAD) (USEPA 2004). For inhalation exposures, recent USEPA RAGS, Part F methodology (2009b) has been used in calculating time-weighted average concentrations, referred to as exposure concentrations (ECs), for contaminants adsorbed onto soil, and released into the air as airborne particulates (i.e., from wind-blown action or mechanical disturbance).

Based on the metal COPCs identified in inaccessible soil, sewer sediment, and inaccessible soil adjacent to sewer lines, as well as the receptor information discussed in Section K2.3.2, CDIs, DADs, and ECs were determined for metal COPCs in these media for the following receptor scenarios:

- industrial worker (SLDS plant/VP employee) exposed to metal COPCs in inaccessible soil at Terminal RR (DT-9) Main Tracks, Thomas and Proetz Lumber (DT-10), and BNSF RR (DT-12);
- construction worker exposed to metal COPCs in inaccessible soil at Terminal RR (DT-9) Main Tracks and BNSF RR (DT-12);
- utility worker (similar to a maintenance or construction worker) exposed to metal COPCs in inaccessible soil elevated measurement areas at Terminal RR (DT-9) Main Tracks and BNSF RR (DT-12);
- sewer maintenance worker exposed to metal COPCs in sediment inside of sewer lines at Plants 1, 2, and 6, and near the McKinley Bridge (DT-11); and
- sewer utility worker exposed to metal COPCs in soil adjacent to sewer lines at Plant 1.

The following presents all general dose equations used to evaluate receptor exposures to metal COPCs in inaccessible soil, sewer sediment, and soil adjacent to sewer lines. However, the equations are not applicable to lead exposures, as explained later in Section K2.4.2.5. Additionally, the inhalation equations below are applicable only to soil, as this pathway is considered to be incomplete for sediment, because releases of sediment particulates into the air are prevented by the high percent moisture content of the sediment. Table K-11 summarizes all receptor-specific exposure parameters used as input values into the dose equations, which includes parameter descriptions, units, numerical values assigned to the parameters, and sources/rationale for the numerical values. Additional subscripting is applied in Table K-11 to the general parameters presented in the equations below to correlate inputs with receptor-specific scenarios.

*Non-carcinogenic Exposures to Soil or Sediment via Incidental Ingestion*

The CDI for a worker exposed to non-carcinogenic metal COPCs via the incidental ingestion of soil or sediment ($CDI_{nc}$) was calculated with the following formula (USEPA 1989a):

$$CDI_{nc} = \frac{C_s \times IR \times CF \times FI \times EF \times ED}{BW \times AT_{nc-ing}}$$

where

$CDI_{nc}$ = chronic daily intake for worker exposures to non-carcinogenic metals in soil or sediment (mg/kg-day),

$C_s$ = metal concentration in soil or sediment (mg/kg),

$IR$ = soil or sediment ingestion rate (mg/day),

$CF$ = conversion factor ($10^{-6}$ kg/mg),

$FI$ = fraction of soil or sediment ingested from contaminated source (unitless),

$EF$ = soil or sediment exposure frequency (days/year),

$ED$ = exposure duration (years),

$BW_a$ = adult body weight (kg),

$AT_{nc-ing}$ = non-carcinogenic averaging time for soil or sediment ingestion exposures (days).

*Non-carcinogenic Exposures to Soil or Sediment via Dermal Contact*

The DAD for a worker exposed to non-carcinogenic metal COPCs via dermal contact ($DAD_{nc}$) with soil or sediment was calculated with the following formula (USEPA 2004):

$$DAD_{nc} = \frac{C_s \times CF \times SA \times AF \times ABS \times EF \times ED \times EV}{BW \times AT_{nc-derm}}$$

where

$DAD_{nc}$ = dermally absorbed dose for worker exposures to non-carcinogenic metals in soil or sediment via dermal contact (mg/kg-day),

$C_s$ = metal concentration in soil or sediment (mg/kg),

$CF =$ conversion factor ($10^{-6}$ kg/mg),

$SA =$ skin surface area available for soil or sediment contact ($cm^2$),

$AF =$ skin adherence factor for soil or sediment contact ($mg/cm^2$-event),

$ABS =$ absorption factor (unitless),

$EF =$ soil or sediment exposure frequency (days/year),

$ED =$ exposure duration (years),

$EV =$ event frequency for soil contact (events/day),

$BW_a =$ adult body weight (kg),

$AT_{nc-derm} =$ non-carcinogenic averaging time for dermal exposures to soil or sediment (days).

*Non-carcinogenic Exposures to Soil via Dust Inhalation*

The EC for a worker exposed to non-carcinogenic soil COPCs via the inhalation of airborne particulates emanating from inaccessible soil areas ($EC_{nc}$) was calculated with the following equation (USEPA 2009b):

$$EC_{nc} = \frac{C_s \times (PEF)^{-1} \times ET \times EF \times ED}{AT_{nc-inh}}$$

where

$EC_{nc} =$ air exposure concentration for worker exposures to non-carcinogenic metals in soil particulates/dusts ($\mu g/m^3$),

$C_s =$ metal concentration in soil ($\mu g/m^3$),

$PEF =$ particulate emission factor ($kg/m^3$),

$ET =$ soil exposure time (hr/day),

$EF =$ soil exposure frequency (days/year),

$ED =$ exposure duration (years),

$AT_{nc-inh} =$ non-carcinogenic averaging time for inhalation exposures to airborne soil particulates/dusts (hr).

*Carcinogenic Exposures to Soil or Sediment via Incidental Ingestion*

The CDI for a worker exposed to carcinogenic metal COPCs via the incidental ingestion of soil or sediment ($CDI_c$) was calculated with the following formula (USEPA 1989a):

$$CDI_c = \frac{C_s \times IR \times CF \times FI \times EF \times ED}{BW \times AT_{c-ing}}$$

where

$CDI_c =$ chronic daily intake for worker exposures to carcinogenic metals in soil or sediment (mg/kg-day),

$C_s =$ metal concentration in soil or sediment (mg/kg),

$IR =$ soil or sediment ingestion rate (mg/day),

$CF =$ conversion factor ($10^{-6}$ kg/mg),

$FI =$ fraction of soil or sediment ingested from contaminated source (unitless),

$EF =$ soil or sediment exposure frequency (days/year),

$ED =$ exposure duration (years),

$BW_a =$ adult body weight (kg),

$AT_{c-ing} =$ carcinogenic averaging time for soil or sediment ingestion exposures (days).

*Carcinogenic Exposures to Soil or Sediment via Dermal Contact*

The DAD for a worker exposed to carcinogenic metal COPCs via dermal contact with soil or sediment ($DAD_c$) was calculated with the following formula (USEPA 2004):

$$DAD_c = \frac{C_s \times CF \times SA \times AF \times ABS \times EF \times ED \times EV}{BW \times AT_{c-derm}}$$

where

$DAD_c =$ dermally absorbed dose for worker exposures to carcinogenic metals in soil or sediment via dermal contact (mg/kg-day),

$C_{sl} =$ metal concentration in soil or sediment (mg/kg),

$CF =$ conversion factor ($10^{-6}$ kg/mg),

$SA =$ skin surface area available for soil or sediment contact (cm$^2$),

$AF =$ skin adherence factor for soil or sediment contact (mg/cm$^2$-event),

$ABS =$ absorption factor (unitless),

$EF =$ soil or sediment exposure frequency (days/year),

$ED =$ exposure duration (years),

$EV =$ event frequency for soil or sediment contact (events/day),

$BW_a =$ adult body weight (kg),

$AT_{c-derm} =$ carcinogenic averaging time for dermal exposures to soil or sediment (days).

*Carcinogenic Exposures to Soil via Dust Inhalation*

The EC for a worker exposed to carcinogenic soil COPCs via the inhalation of airborne particulates emanating from inaccessible soil areas ($EC_c$) was calculated with the following equation (USEPA 2009b):

$$EC_c = \frac{C_s \times (PEF)^{-1} \times ET \times EF \times ED}{AT_{c-inh}}$$

where

$EC_c =$ air exposure concentration for worker exposures to non-carcinogenic metals in soil particulates/dusts ($\mu g/m^3$),

$C_s =$ metal concentration in soil ($\mu g/m^3$),

$PEF =$ particulate emission factor ($kg/m^3$),

$ET =$ soil exposure time (hr/day),

$EF =$ soil exposure frequency (days/year),

$ED =$ exposure duration (years),

$AT_{c-inh} =$ carcinogenic averaging time for inhalation exposures to airborne soil particulates/dusts (hr).

## K2.4 TOXICITY ASSESSMENT

The toxicity assessment identifies the toxicity values [e.g., cancer slope factors (CSFs) and reference doses (RfDs)] for COPCs identified in ISOU media. These toxicity values were applied to the estimated doses (intakes) to quantify carcinogenic and non-carcinogenic risks. For radiological evaluations, the source of slope factors (SFs) used in the RESRAD and RESRAD-Build evaluations is Federal Guidance Report (FGR) 13.

In accordance with the hierarchy of sources established by USEPA (2003a) for obtaining chemical toxicity values for metal COPCs, USEPA's *Integrated Risk Information System* (IRIS) (USEPA 2011b) was used as the preferred source. The IRIS website is continuously updated to reflect the latest toxicological information that is currently available and derived from the results of studies recognized by USEPA as being of a sufficient degree of confidence for use in risk assessments. Generally, USEPA recommends the following three-tiered hierarchy of toxicological data sources from which to select toxicity criteria for the inhalation exposure route (as well as all routes):

- Tier 1 – USEPA's on-line IRIS database;
- Tier 2 – Provisional Peer-Reviewed Toxicity Values derived by USEPA's Superfund Health Risk Technical Support Center for the Superfund program; and
- Tier 3 – Other toxicity criteria as recommended by USEPA's National Center for Environmental Assessment, such as the California Environmental Protection Agency toxicity values, the Agency for Toxic Substances and Disease Registry's minimal risk levels, and Health Effects Assessment Summary Tables (USEPA 1995b) toxicity values.

### K2.4.1 Radiological Toxicity Assessment

Health impacts from exposure to radiation and radionuclides are expressed as the risk of developing cancer and have been determined using the RESRAD computer code. Because radiological exposures result in cancer, CRs from exposures to ISOU radiological PCOCs have been estimated using USEPA SFs developed for inhalation, ingestion, and external radiation exposure routes. The radiological SFs specific to each exposure route are used to convert exposure to CR.

SFs for radionuclides are defined differently than SFs for metals. USEPA outlines these differences in the Radiation Exposure and Risk Assessment Manual (USEPA 1996b). Major differences include the following:

- The radiological endpoint is fatal cancer – the endpoint for metal exposures is tumorigenic cancer or non-carcinogenic risk.
- Radiological risk estimates are based primarily on human data – metals risk estimates are based primarily on animal studies.
- Radiological risk estimates are based on the central estimate of the mean – metals risk estimates are based on the 95% UCL of the mean.

A dose conversion factor for radiological exposures was used to calculate lifetime committed effective dose equivalents. Radiological doses were calculated to ensure compliance with ARARs to be identified for radiological contamination. For a site to be released for unrestricted use, Title 10 *CFR* Part 20, Subpart E requires the radiological dose to be less than 25 mrem/yr, which is approximately equivalent to a CR of 5.0E-04 (USEPA 1997b). The appropriate dose limit will be determined during ARARs development in the FS.

All radiological SFs used in this ISOU BRA are presented in Table K-12.

### K2.4.2 Toxicity Assessment for Metals

The following sections discuss and present information relevant to the evaluation of toxicities of the metal COPCs identified in ISOU media.

#### *K2.4.2.1 Cancer Toxicity Assessment for Metal Contaminants of Potential Concern*

USEPA SFs used for estimating CRs for metal compounds are upper 95$^{th}$ percentile confidence limits of the probability of response per unit intake (by oral or inhalation routes) over a lifetime. SFs for metals are based on mathematical extrapolation from experimental animal data and epidemiological studies, when available. SFs are expressed in units of risk per milligram metal intake per kilogram body weight per day or (mg/kg-day)$^{-1}$. Because SFs are upper-bound estimates, actual cancer potency of PCOCs are likely lower than estimated (USEPA 1989a).

#### *K2.4.2.2 Non-cancer Toxicity Assessment for Metal Contaminants of Potential Concern*

The RfD is an exposure route-specific estimate of a daily intake per unit body weight that is likely to be without deleterious effects (USEPA 1989a). USEPA derives RfDs to protect sensitive populations, such as children, and has developed many chronic RfDs to evaluate long-term exposures (seven years to a lifetime) and a few subchronic RfDs to evaluate exposures of shorter duration (two weeks to seven years).

#### *K2.4.2.3 Dermal Toxicity Assessment for Metal Contaminants of Potential Concern*

There are no toxicity values specific to dermal exposure; therefore, USEPA recommends that oral toxicity values be used to assess risks from dermal exposure. The approach is described in USEPA guidance (1989a). The oral toxicity factor for a metal relates toxic response to an administered dose of only some metals of which may be absorbed by the body; whereas, intake from dermal contact is estimated as an absorbed dose using chemical-specific permeability constants for absorption from water and dermal-absorbed fraction from soil (USEPA 2004). To ensure that dermal toxicity is not underestimated, USEPA recommends adjusting oral toxicity factors by chemical-specific GI absorption fractions (GIABS) to evaluate toxic effects of a DAD

(USEPA 2004). Oral RfDs ($RfD_o$) are adjusted to derive dermal RfDs ($RfD_d$) using the following equation:

$$RfD_d = RfD_o \times GIABS$$

Oral SFs ($SF_o$) are adjusted to derive dermal SFs ($SF_d$) using the following equation:

$$SF_d = \frac{SF_o}{GIABS}$$

*K2.4.2.4 Inhalation Toxicity Assessment for Metal Contaminants of Potential Concern*

Recent USEPA guidance for evaluating the inhalation exposure pathway (USEPA 2009b) recommends the use of carcinogenic inhalation unit risk (IUR) and non-carcinogenic reference concentration (RfC) values.

The IUR is defined as the upper-bound excess lifetime CR estimated to result from continuous exposure to an agent at a concentration of 1 μg/m$^3$ in air. IURs are expressed in units of (mg/m$^3$)$^{-1}$.

The inhalation RfC is defined as an estimate of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to not result in a significant risk of systemic effects during a lifetime. Estimates of RfCs are associated with uncertainty spanning approximately an order of magnitude. The RfC can be derived from a no observed adverse effects level (NOAEL), a lowest observed adverse effects level (LOAEL), or benchmark concentration. Various types of RfCs are available depending on the type of critical effect and the length of exposure being evaluated (chronic or subchronic).

*K2.4.2.5 Toxicity Assessment for Lead*

Lead was identified as a COPC for several soil adjacent to sewers locations within the Plants 1, 2, and 6 properties based on exceedances of the industrial screening level, which corresponds to USEPA's (2011a) industrial soil RSL. USEPA's risk assessment methodology for lead is unique because toxicological reference values (i.e., SFs or RfDs) are not available. Because the fate of lead in the body (absorption, distribution, metabolism, and excretion) is fairly well understood, USEPA evaluates lead in soil based on actual or predictive blood lead concentrations. USEPA and the Centers for Disease Control have determined that child blood lead concentrations at or above 10 micrograms of lead per deciliter of blood (μg/dL) present risks to children's health. For an occupational scenario, the USEPA risk reduction goal is to protect the fetus of a pregnant adult female from exposures that could result in the probability of the fetal blood lead concentration from exceeding 10 μg/dL to less than or equal to 5% of the population. In order to evaluate the potential for blood lead concentrations to exceed 10 μg/dL, individual sample concentrations observed at the elevated sewer soil locations have been compared to USEPA's (2011a) industrial RSL of 800 mg/kg. The lead RSL corresponds to a 5% benchmark probability of exceeding a fetal blood lead level of 10 μg/dL, as determined using the Adult Lead Methodology (ALM), a model developed by USEPA's Technical Review Workgroup for Lead (USEPA 2003b). USEPA considers this benchmark to be protective of a fetus carried by a pregnant worker. It is assumed that a screening level protective of a fetus will also afford protection for male and female adult workers.

*K2.4.2.6 Toxicity Information for Metal COPCs*

All numerical toxicity criteria and information for metal COPCs are presented in Tables K-13A through K-13C, with the following information being presented for each PCOC, as appropriate: weight-of-evidence classification, tumor site(s), unit risk values, uncertainty factors, modifying factors, and non-carcinogenic target organs/critical effects.

## K2.5 DOSE AND RISK CHARACTERIZATION

The objective of risk characterization is to integrate the information developed in the exposure assessment and the toxicity assessment into an evaluation of the potential current and future health risks associated with radiological and metal COPCs. In this step, the toxicity factors (SFs and RfDs) are applied in conjunction with dose to estimate potential carcinogenic health risks (radiological and metal COPCs) and non-carcinogenic hazards (metal COPCs). Sections K2.5.1 and K2.5.2 describe how the carcinogenic and non-carcinogenic risk calculations were performed, respectively. Determination of carcinogenic risks from exposures to radiological contamination in inaccessible soil and on building surfaces was performed using the RESRAD (Version 6.5) and RESRAD-Build (Version 3.5) models, respectively. Appendices O and P present RESRAD and RESRAD-Build output files, respectively, from the radiological dose and risk evaluations of all receptors. Appendix Q presents risk calculation spreadsheets for evaluating exposures to metal COPCs for all receptors.

### K2.5.1 Estimation of Carcinogenic Risk from Radiological and Metal Exposures

The potential for carcinogenic effects was characterized in terms of the incremental probability of an individual developing cancer over a lifetime as a result of site-related exposure to a potential carcinogen. CRs for radiological COPCs were estimated based on SFs that reflect morbidity. For metals, excess lifetime CRs were estimated from the projected lifetime daily average intake and the carcinogenic SF or IUR, which represents an upper-bound estimate of the dose-response relationship.

Generally, excess lifetime CR for carcinogenic effects is calculated by multiplying the estimated dose (i.e., lifetime-averaged daily intake for metals, and average annual dose for radionuclides) via an exposure route by the exposure route-specific (oral, inhalation, dermal, or external radiation) carcinogenic SF or IUR, as described below.

$$CR = Dose \times Toxicity\ Value$$

where:

$CR$ = Cancer risk (unitless);
$Dose$ = Oral chronic daily intake (CDI, mg/kg-day), dermal absorbed dose (DAD, mg/kg/day), or air exposure concentration (EC, $\mu g/m^3$) for inhalation;
$Toxicity\ Value$ = Oral or dermally adjusted cancer slope factor [$SF_o$ or $SF_d$, $(mg/kg\text{-}day)^{-1}$] or inhalation unit risk (IUR $\mu g/m^3$).

The CRs resulting from exposure to multiple carcinogens are assumed to be additive. However, because SFs and IURs for radionuclides and metals are specific to distinct models that incorporate different assumptions (as indicated above), USEPA's RAGS guidance (1989a) cautions against combining (i.e., summing) radiological CRs with metal CRs. In addition, natural background radiation is ubiquitous at levels exceeding typical risk targets, and natural variability may preclude the ability to quantify small incremental CRs due to contamination. Therefore, total CRs to be calculated for radiological and metal COPCs are assessed separately and are not summed together for estimation of cumulative CRs.

USEPA policy must be considered to interpret the significance of the CR estimates. In the NCP (USEPA 1990), USEPA states that for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime CR of between 1.0E-06 and 1.0E-04. Although USEPA's (1990) NCP identifies 1.0E-06 as the point of departure for all CR evaluations, the CR of 1.0E-05 represents the mid-point of USEPA's acceptable target CR range of 1.0E-06 to 1.0E-04. Application of the target CR of 1.0E-05 is consistent with the current and expected future land use of the SLDS as a heavily industrial area in an urban setting, and facilitates the identification of those SLDS properties and elevated measurement areas that should be retained for further evaluation in the FS.

### K2.5.2 Estimation of Non-carcinogenic Hazard for Metal Exposures

The potential for non-carcinogenic health effects resulting from exposures to individual metal COPCs was evaluated by the calculation of an HQ. An HQ is the ratio of the exposure duration-averaged estimated daily intake through a given exposure route, to the chemical and route-specific (i.e., oral, inhalation, or dermal) RfD or RfC, calculated as presented below.

$$HQ = \frac{Dose}{Toxicity\ Value} \text{HQ = Exposure/Toxicity Value}$$

where:

$HQ =$ hazard quotient (unitless);
$Dose =$ Oral chronic daily intake (CDI, mg/kg-day), or dermally absorbed dose (DAD, mg/kg/day), or air exposure concentration (EC, μg/m$^3$) for inhalation;
$Toxicity\ Value =$ Oral or dermally adjusted reference dose (RfD$_o$ or RfD$_d$, μg/kg-day) or inhalation reference concentration (RfC, mg/m$^3$).

Use of the RfD or RfC assumes that there is a level of intake (the RfD or RfC) below which it is unlikely that even sensitive individuals, such as children, will experience adverse health effects over the period of exposure. If the average daily intake exceeds the RfD or RfC (i.e., if the HQ exceeds 1.0), then there may be cause for concern for potential non-cancer, systemic effects (USEPA 1989a). It should be noted, however, that the level of concern does not increase linearly as the RfD or RfC is approached or exceeded. Because the HQ does not define a dose-response relationship, its numerical value cannot be construed as a direct estimate of risk (USEPA 1989a). Rather, an HQ greater than 1.0 indicates a potential cause for concern for non-cancer health effects, which might indicate the need for re-evaluating actual exposure conditions or concentrations or consideration of risk management alternatives.

To assess pathway-specific exposures to multiple metals, the HQs over all metal COPCs are summed to yield an HI. The assumption of additive effects reflected in the HI is most properly applied to substances that induce the same effect by the same biological mechanism (USEPA 1989a). Consequently, summing HQs for substances that are not expected to induce the same type of toxic effect will overestimate the potential for adverse health effects. The HI provides a measure of the potential for adverse effects but it is conservative and dependent on the quality of experimental evidence.

If a receptor is exposed by multiple pathways, then the HIs from all relevant pathways are summed to obtain the total HI for that receptor. If the total HI ≤1.0, then multiple-pathway exposures to COPCs at the site will be judged unlikely to result in an adverse effect. If the sum >1.0, then further evaluation of exposure assumptions and toxicity, including consideration of specific target organs affected and mechanisms of toxic actions of COPCs, are warranted to ascertain if the cumulative exposure would, in fact, be likely to harm exposed individuals. However, given that arsenic and cadmium are the only two metal COPCs being evaluated, and they affect different target organs, the evaluation of target organs and critical effects was not necessary in this HHRA.

### K2.5.3 Risk and Dose Characterization of the Inaccessible Soil Operable Unit

Sections K2.5.3.1 through K2.5.3.8 describe the medium- and property-specific radiological and metal dose and risk results, by receptor scenarios that have been determined for the SLDS ISOU. Based on COPC and exposure pathway information provided in the previous sections, the following scenarios were evaluated for risk and dose and are discussed in the sections indicated:

- industrial worker (SLDS plant/VP employee) exposed to radiological and metal COPCs in all inaccessible soil at each of the plant properties, industrial/commercial VPs [including the St. Louis City Property (DT-2)], RR properties, and roadways (i.e., Tier 1 inaccessible soil evaluation, Section K2.5.3.1);
- industrial worker (SLDS plant/VP employee) exposed to radiological and metal COPCs in property-wide, combined inaccessible and accessible soil at plant properties and industrial/commercial VPs [including the St. Louis City Property (DT-2)] that exceed dose, CR, or HI target criteria estimated for all inaccessible soil at each property (i.e., Tier 2 evaluation per Figure K-1) (Section K2.5.3.2);
- construction worker exposed to radiological and metal COPCs in all inaccessible soil at RR properties and roadways (Section K2.5.3.3);
- utility worker exposed to radiological and metal COPCs in inaccessible soil elevated measurement areas at all plant properties, industrial/commercial VPs [including the St. Louis City Property (DT-2)], RR properties, and roadways (Section K2.5.3.4);
- recreational user exposed to radiological COPCs in all inaccessible soil at the St. Louis City Property (DT-2) (Section K2.5.3.5);
- industrial worker (SLDS plant/VP employee) exposed to radiological COPCs in soil on exterior surfaces of buildings/structures (Section K2.5.3.6);
- sewer maintenance worker exposed to metal COPCs in sediment inside of sewer lines at Plants 1, 2, and 6, and near the McKinley Bridge (DT-11) (as a note, no radiological COPCs were identified for sewer sediment) (Section K2.5.3.7); and
- sewer utility worker exposed to radiological and metal COPCs in soil adjacent to sewer lines at Plants 1, 2, 6, 7/BNSF RR (DT-12), and the St. Louis City Property (DT-2), which include evaluations at individual soil borings and sewer line excavations (Section K2.5.3.8).

The radiological doses and risks discussed for the scenarios below represent the maximum total doses and risks estimated to occur over the 1,000-year evaluation period.

#### *K2.5.3.1 Industrial Worker Exposures to Radiological and Metal Contaminants of Potential Concern in Inaccessible Soil at All Properties (Tier 1 Evaluation)*

Table K-14A presents the total maximum radiological dose and CR results, estimated to occur over the 1,000-year evaluation period, for inaccessible soil exposures to industrial workers at a total of 15 properties (three plant properties, four industrial/commercial VPs, three RR properties [with the three portions of the Terminal RR being counted as one property], and five roadways). For the plant properties and industrial/commercial VPs, this evaluation is part of the Tier 1 inaccessible soil evaluation identified in Figure K-1. The maximum total doses estimated for Plant 1 (31 mrem/yr) and Gunther Salt (DT-4) North (48 mrem/yr) exceeded the target criterion of 25 mrem/yr. The RESRAD outputs presented in Appendix O indicate that the maximum external radiation doses predicted for the following radionuclides, along with time of maximum occurrence (years) in parentheses, contribute predominantly to the overall total maximum doses estimated for the industrial worker at Plant 1 and DT-4:

- Plant 1 – Ra-226 (0 years), and
- DT-4 – Ra-226 (0 years).

The maximum total CRs estimated for all properties evaluated, except for PSC Metals, Inc. (DT-8), exceeded the target criterion of 1.0E-05. The RESRAD outputs presented in Appendix O for the industrial worker scenario for each of the properties below indicate that the maximum external radiation CRs contributed predominantly to all maximum total CRs. The following presents the predominant risk-driving radionuclides, along with time of maximum occurrence (years) in parentheses, for each property:

- Plant 1 – Ra-226 (0 years),
- Plant 2 – Th-230 in-growth (1,000 years),
- Plant 6 – Ra-226 (0 years),
- St. Louis City Property (DT-2) – Ra-226 (0 years),
- Gunther Salt (DT-4) North – Th-230 in-growth (1,000 years),
- Heintz Steel (DT-6) – Th-230 in-growth (1,000 years),
- Norfolk Southern RR (DT-3) – Th-230 in-growth (1,000 years),
- Terminal RR (DT-9) Main Line – Th-232 in-growth (1,000 years),
- Terminal RR (DT-9) Rail Yard – Ra-226 (0 years),
- Terminal RR Soil Spoils Area – Th-230 in-growth (1,000 years),
- BNSF RR (DT-12) – Th-230 in-growth (1,000 years),
- Angelrodt Street – Th-230 in-growth (1,000 years),
- Destrehan Street – Th-230 in-growth (1,000 years),
- Hall Street – Ra-226 (0 years),
- Mallinckrodt Street – Th-232 in-growth (1,000 years), and
- North Second Street – Th-230 in-growth (1,000 years).

Based on the radiological dose and risk results, all 3 plant properties, 3 of the 4 evaluated industrial/commercial VPs, and all RR properties and roadways are retained for the Tier 2 property-wide, combined inaccessible and accessible soil evaluations for the industrial worker (see Figure K-1), the results of which are discussed in Section K2.5.3.2.

Table K-14B presents the CRs and HIs estimated for exposures to metal COPCs in inaccessible soil to industrial workers at the Terminal RR (DT-9) Main Line, Thomas and Proetz Lumber (DT-10), and the BNSF RR (DT-12). The CRs estimated for Thomas and Proetz Lumber (DT-10) (2.7E-05) and the BNSF RR (DT-12) (2.7E-05) exceeded the target CR of 1.0E-05 due to arsenic exposures via the ingestion route of exposure. Consequently, arsenic at the Thomas and Proetz Lumber (DT-10) is retained for the Tier 2 property-wide, combined inaccessible and accessible soil evaluations for the industrial worker (see Figure K-1), the results of which are discussed in Section K2.5.3.2. Additionally, arsenic exposures to the construction worker are evaluated at all investigated inaccessible soil areas within the BNSF RR (DT-12), the results of which are discussed in Section K2.5.3.3.

In summary, of the three plant properties and five industrial/commercial VPs evaluated for radiological and/or metals exposures to inaccessible soil, all three plant properties, four of the industrial/commercial VPs, and all RR properties and roadways were retained for Tier 2 evaluations of combined, property-wide inaccessible and accessible soil, as discussed in Section K2.5.3.2.

*K2.5.3.2 Property-Wide Industrial Worker Exposures to Radiological and Metal Contaminants of Potential Concern in Combined Inaccessible and Accessible Soil at All Properties (Tier 2 Evaluation)*

Based on the exceedances of target dose and CR criteria estimated for inaccessible soil at three plant properties and four industrial/commercial VPs, and all RR properties and roadways during the Tier 1 evaluations, property-wide EPCs were estimated for each of the properties by calculating the area-weighted average of inaccessible soil and accessible soil EPCs for use in the Tier 2 evaluations (see Figure K-1). The combined, area-weighted EPCs for radiological and metal COPCs are presented in Tables K-15A and K-15B, respectively.

Table K-16A presents the Tier 2 total maximum radiological dose and CR results, estimated to occur over the 1,000-year evaluation period, for combined, property-wide inaccessible and accessible soil exposures to industrial workers at the three plant properties, three industrial/commercial VPs, three RR properties, and five roadways. The maximum total doses estimated for all properties, except for Gunther Salt (DT-4) North (28 mrem/yr), were below 25 mrem/yr. The RESRAD outputs presented in Appendix O indicate that the maximum external radiation dose predicted for the following radionuclides, along with time of maximum occurrence (years) in parentheses, contribute predominantly to the overall total maximum dose estimated for the Tier 2 industrial worker scenario at DT-4:

- Gunther Salt (DT-4) North – Th-230 in-growth (1,000 years).

The maximum total CRs estimated for all properties evaluated, except for Plant 2, exceeded the target criterion of 1.0E-05. The RESRAD outputs presented in Appendix O for the industrial worker scenario for each of the properties below indicate that the maximum external radiation CRs contributed predominantly to all maximum total CRs. The following presents the predominant risk-driving radionuclides, along with time of maximum occurrence (years) in parentheses, for each property:

- Plant 1 – Ra-226 (0 years),
- Plant 6 – Ra-226 (0 years),
- St. Louis City Property (DT-2) – Th-230 in-growth (1,000 years),
- Gunther Salt (DT-4) North – Th-230 in-growth (1,000 years),
- Heintz Steel (DT-6) – Th-230 in-growth (1,000 years),
- Norfolk Southern RR (DT-3) – Th-230 in-growth (1,000 years),
- Terminal RR (DT-9) Main Line – Th-232 in-growth (1,000 years),
- Terminal RR (DT-9) Rail Yard – Ra-226 (0 years),
- Terminal RR Soil Spoils Area – Th-230 in-growth (1,000 years),
- BNSF RR (DT-12) – Th-230 in-growth (1,000 years),

- Angelrodt Street – Th-230 in-growth (1,000 years),
- Destrehan Street – Th-230 in-growth (1,000 years),
- Hall Street – Ra-226 (0 years),
- Mallinckrodt Street – Th-232 in-growth (1,000 years), and
- North Second Street – Th-230 in-growth (1,000 years).

Table K-16B presents the CRs and HIs estimated for industrial worker exposures to arsenic in combined, property-wide inaccessible and accessible soil at Thomas and Proetz Lumber (DT-10). Because no arsenic data exist for accessible soil at BNSF RR (DT-12), a Tier 2 evaluation was not conducted. Both the CR and HI were below target risk criteria.

In summary, of the three plant properties and four industrial/commercial VPs evaluated under Tier 2 for industrial worker exposures to combined, property-wide inaccessible and accessible soil, two of the three evaluated plant properties and three of the four evaluated industrial/commercial VPs are retained for further evaluation in the FS.

*K2.5.3.3 Construction Worker Exposures to Radiological and Metal Contaminants of Potential Concern in Inaccessible Soil at Railroad Properties and Roadways*

Table K-17A presents the total maximum radiological dose and CR results, estimated to occur over the 1,000-year evaluation period, for inaccessible soil exposures to construction workers at the three RR properties (with the three portions of the Terminal RR being counted as one property) and five roadways. All doses and CRs estimated for these properties were less than target dose and CR criteria.

Table K-17B presents the CRs and HIs estimated for construction worker exposures to metal COPCs in inaccessible soil at the Terminal RR (DT-9) Main Tracks and BNSF RR (DT-12). All CRs and HIs estimated for both RR properties were below target risk criteria.

In summary, all doses, CRs, and HIs estimated for construction worker exposures to inaccessible soil at the three RR properties and five roadways are below target criteria. However, because the CRs estimated for industrial worker exposures to inaccessible soil at these properties exceed the target CR of 1.0E-05, all three RR properties and the five roadways are retained for further evaluation in the FS.

*K2.5.3.4 Utility Worker Exposures to Radiological and Metal Contaminants of Potential Concern in Inaccessible Soil Elevated Measurement Areas at All Properties*

Table K-18A presents the total maximum radiological dose and CR results, estimated to occur over the 1,000-year evaluation period, for inaccessible soil exposures to utility workers at 35 elevated measurement areas across all SLDS properties. The maximum total doses estimated for all properties were below the target dose criterion of 25 mrem/yr.

The maximum total CRs estimated for all elevated measurement areas, except for soil beneath Building 26 at Plant 1 (1.4E-05), are less than target criterion of 1.0E-05. The RESRAD output presented in Appendix O for the utility worker scenario at Building 26 indicate that the maximum external radiation CRs contributed predominantly to all maximum total CRs. The following presents the predominant risk-driving radionuclides, along with time of maximum occurrence (years) in parentheses:

- Plant 1, Building 26 – Ra-226 (0 years).

Table K-18B presents the CRs and HIs estimated for utility worker exposures to metal COPCs in inaccessible soil elevated measurement areas at the Terminal RR (DT-9) Main Tracks between

Plants 2 and 6W; Thomas and Proetz Lumber (DT-10), around the office building; and BNSF RR (DT-12), adjacent to Plants 6 and 7. All CRs and HIs estimated for the three elevated measurement areas are below target CR and HI criteria.

In summary, only the inaccessible soil elevated measurement area beneath Building 26 at Plant 1 exceeds the target CR criterion of 1.0E-05 and is therefore, being retained for further evaluation in the FS.

*K2.5.3.5 Recreational User Exposed to Radiological Contaminants of Potential Concern in Inaccessible Soil at the St. Louis City Property (DT-2) (Tiers 1 and 2 Evaluations)*

Table K-19 presents the total maximum radiological dose and CR results, estimated during the Tier 1 evaluation to occur over the 1,000-year evaluation period, for inaccessible soil exposures to adolescent recreational users of the St. Louis City Property (DT-2). Also presented are the Tier 2 evaluation results. In both tiers of evaluations, the maximum total doses and the maximum total CRs are below the target criteria of 25 mrem/yr and 1.0E-05, respectively. Therefore, no further evaluation of this scenario is needed.

*K2.5.3.6 Industrial Worker Exposures to Radiological Contaminants of Potential Concern in Soil on Exterior Surfaces of Buildings/Structures*

No radionuclide-specific COPCs were identified for building surfaces because only gross alpha measurements were obtained during building surveys, which were compared to the screening level of 3,900 dpm/100 $cm^2$ derived as part of the RI WP (USACE 2009a). Based on the screening level exceedances, only the surveyed exterior surfaces of the following buildings were retained for radiological dose and risk evaluation in the HHRA: Building 25 (Plant 1), the Wood Storage Building at Thomas and Proetz Lumber Company (DT-10), and the horizontal beam between L-shaped building and brick warehouse at Cotto-Waxo Company (DT-14).

The EPCs determined for gross alpha measurements were converted to radionuclide-specific surface concentrations (pCi/$m^2$) through unit conversions and subsequent applications of SLDS-specific activity fractions. The resulting radionuclide-specific EPCs were then entered into the RESRAD-Build model to calculate total maximum doses and risks associated with external radiation exposures to SLDS plant/VP employees, which are presented in Table K-20.

The maximum total doses and CRs determined for all exterior building surfaces are less than the target benchmark values of 25 mrem/yr and 1.0E-05, respectively. Consequently, no further evaluation of soil on external surfaces of buildings/structures is needed.

*K2.5.3.7 Sewer Maintenance Worker Exposures to Metal Contaminants of Potential Concern in Sewer Sediment*

Sewer maintenance workers were evaluated for exposures to arsenic and/or cadmium, which were identified as COPCs in sewer sediment at 15 out of 26 sampled on-site locations within Plants 1, 2, 6, and near the McKinley Bridge (DT-11). Arsenic was identified as a COPC at all 15 locations and cadmium was a COPC at 1 location (SLD123489). As stated previously in Section K2.2, no radiological COPCs were identified for sewer sediment because the $SOR_N$ value determined at each location was less than the target value of 1.0. Table K-21 shows that all total CRs and HIs estimated for arsenic and cadmium are less than the target values of 1.0E-05 and 1.0, respectively.

##### *K2.5.3.8 Sewer Utility Worker Exposures to Radiological and Metal Contaminants of Potential Concern in Soil Adjacent to Sewer Lines*

Sewer utility workers were evaluated for inaccessible soil exposures at locations adjacent to existing sewer lines at Plants 1, 2, 6, 7/BNSF RR (DT-12), and the St. Louis City Property (DT-2). A total of 28 on-site boring locations were sampled, along with three sewer line excavation areas. Based on screening level exceedances, six boring locations and all three excavation areas were evaluated in the HHRA for radiological and/or metal exposures.

Table K-22A shows that the maximum total doses estimated for Plant 1 (location SLD124540) and the sewer excavation in the northwest corner of Plant 6 are less than the 25-mrem/yr benchmark. However, the doses estimated for the St. Louis City Property (DT-2) sewer line beneath the levee (31 mrem/yr) and the Plant 7N/BNSF RR (DT-12) sewer line excavation (259 mrem/yr) exceed the target dose limit. The RESRAD outputs presented in Appendix O indicate that the maximum external radiation dose estimated for Th-230 in-growth (1,000 years) contributes predominantly to the overall total maximum dose estimated for both sewer excavations.

The maximum total CRs for sewer line excavations in the northwest corner of Plant 6 (1.1E-05), DT-2 (2.3E-05), and Plant 7N/BNSF RR (DT-12) (1.9E-04) all exceed the target CR of 1.0E-05. The RESRAD outputs presented in Appendix O indicate that the maximum external radiation CR estimated for Th-230 in-growth (1,000 years) contributes predominantly to the overall total maximum total CR estimated for the three sewer excavations.

Table K-22B shows the total CRs and HIs estimated for a sewer utility worker at five inaccessible sewer soil borehole locations in Plant 1 and one location in Plant 6. All total CRs and HIs are less than the target values of 1.0E-05 and 1.0, respectively.

Additionally, lead was identified as a sewer soil COPC based on exceedances of the 800-mg/kg industrial screening level at three Plant 1 locations [SLD124540 (6 to 9 ft), SLD124560 (14 to 14.5 ft), and SLD124570 (8 to 8.5 ft)], one Plant 2 location [SLD124576 (3.5 to 4 ft)], and one Plant 6W location [SLD127572 (6 to 6.5 ft)]. However, because of the unique toxicological properties of lead, risk is not quantitatively evaluated for this COPC, as was discussed in Section 6.4.2.5. Therefore, the exceedance of the industrial screening level indicates the potential for health risks to future construction workers exposed to lead in inaccessible soil at the aforementioned locations.

## K2.6 UNCERTAINTIES ANALYSIS

There are a number of factors that contribute uncertainty to the estimates of dose and risk presented in Section K2.5. These uncertainties are inherent to each of the main components of the risk assessment process, as described in the following subsections.

### K2.6.1 Sampling and Dataset Uncertainties

A combination of biased and random sampling strategies was employed for investigating the SLDS ISOU media in an attempt to reduce uncertainties with characterizing media that could be impacted, either directly or indirectly, from past MED/AEC operations. The objective of reducing these uncertainties was to develop a health-conservative risk assessment that would not underestimate actual risks to potentially exposed populations. The criteria used for determining locations of biased samples in ISOU media are presented in the RI WP (USACE 2009a).

Because of the limited access to ISOU media, contamination can be characterized but may not be fully delineated. It is unknown if this tends to over- or underestimate potential human health risks to likely ISOU receptors. Certainly, datasets of limited size that were generated around elevated measurement areas could have potentially resulted in overestimations of risks due to a relatively large standard deviations elevating the 95% UCLs and consequently, the EPCs. In some cases, the 95% UCLs were elevated enough to be greater than the maximum detected concentration, in which case, the maximum concentration becomes the default EPC. Although a health-conservative risk assessment is desired in the CERCLA process, a lack of sample coverage does not adequately represent the probability of actual exposures as a receptor moves randomly about the evaluated area/building.

### K2.6.2 Analytical Data Quality

Some unavoidable uncertainty is associated with the contaminant concentrations detected and reported by the analytical laboratory. The quality of the analytical data used in the risk assessment depends on the adequacy of the set of procedures that specifies how samples are selected and handled and how strictly these procedures are followed. QA/QC procedures within the laboratories are used to minimize uncertainties; however, sampling errors, laboratory analysis errors, and data analysis errors can occur.

Some current analytical methods are limited in their ability to achieve detection limits at or below risk-based screening levels. Under these circumstances, it is uncertain whether the true concentration is above or below the screening levels, which are protective of human health. Generally, analytes identified as COPCs associated with datasets consisting of a mixture of detected and non-detected concentrations and risk calculations may be affected by the reported detection limits. Risks may be overestimated as a result of some sample concentrations being reported as non-detected at the maximum detected concentration or MDL, which may be greater than the screening level (when the actual concentration may be much smaller than the maximum detected concentration or MDL). Risks also may be underestimated because some analytes that are not detected in any sample are removed from the COPC list. If the concentrations of these analytes are below the maximum detected concentration or MDL but are above the screening levels, the risk from these analytes would not be included in the risk assessment results. However, for the ISOU, COPCs were selected based on exceedances of Uranium Mill Tailings Radiation Control Act and industrial risk-based screening levels. These screening levels are sufficiently elevated so that they were not generally exceeded by detection limits. Therefore, the aforementioned uncertainties regarding screening levels and detection limits did not result in significant uncertainties in COPC selection and subsequent risk evaluations.

### K2.6.3 Selection of Contaminants of Potential Concern

The list of COPCs evaluated for the ISOU media is based on the list of radionuclides and metals associated with past MED/AEC operations and on those constituents that were identified as COCs in the 1998 ROD (USACE 1998a). During the 1993 BRA (DOE 1993), other constituents, including VOCs, polycyclic aromatic hydrocarbons, and other metals (antimony, beryllium, cobalt, copper, and nickel), were detected in the soil but either did not significantly contribute risk (e.g., VOCs) or did contribute risk but were not included on the COC list in the 1998 FS (USACE 1998b) and subsequent 1998 ROD because they were determined to not be MED/AEC-related constituents (e.g., antimony, copper, nickel, and polycyclic aromatic hydrocarbons). For consistency with the June 1990 FFA, constituents not directly associated with former MED/AEC operations, or constituents that are not mixed or commingled in the investigated ISOU media with MED/AEC-related constituents, were not evaluated in this HHRA even if CRs or HIs were determined to be above USEPA target criteria during the 1993 BRA.

Besides having been associated with MED/AEC operations, COPCs were identified in ISOU media as those radiological and metal constituents detected at concentrations exceeding the screening levels presented in Table 4-1. For radiological constituents in soil, exceedances of screening levels by individual radionuclides had to result in $SOR_N$ values that, in turn, exceeded the target value of 1.0. For exterior building surfaces, all gross alpha measurements were compared to a screening level of 3,900 dpm/100 $cm^2$, which was derived based on an interior industrial worker scenario during the RI WP (USACE 2009a). A building surface was retained for further risk evaluation if a gross alpha result exceeded the interior surface screening level. Use of the interior surface screening level for exterior building data comparisons is considered to be health conservative for the following reasons:

- The screening level was derived for an industrial worker scenario, which was determined to be the limiting scenario for radiological exposures to building surfaces because exposures are assumed to occur for 2,000 hr/year throughout a 25-year duration of employment.
- The indoor room scenario assumes exposures to five surfaces during each event, representing a combined area of 180 $m^2$ (100-$m^2$ floor, and four, 20 $m^2$-walls) where the receptor is located in the center of the floor; whereas, exposures to exterior surfaces are likely to occur from one surface per event.
- The screening level assumes 20% removable activity, which is a consistent value used for other SLS building scenarios; whereas, smear testing in the field indicates 0% removable activity. The higher removable activity will contribute to greater inhalation exposures to surface activities in the dose and risk evaluations.
- The screening level assumes exposures via ingestion, inhalation, and external radiation; whereas, external radiation is likely to be the dominant route.

### K2.6.4 Exposure Assessment

Quantification of exposure provides an estimate of the chemical intake for various exposure pathways identified at the site. For the ISOU HHRA, uncertainties associated with the various components of the exposure assessment include those related to representative EPCs and exposure parameters.

#### *K2.6.4.1 Soil Exposure Areas and Exposure Point Concentrations*

Uncertainty is also introduced through the process of estimating representative EPCs in the analyzed exposure media. However, prior to calculating EPCs, exposure areas are determined. Inaccessible and accessible soil exposure areas were determined for each property/receptor scenario. Obtaining adequate sample coverage in inaccessible areas was largely a function of field conditions during sampling events. Inaccessible areas with low coverage introduced EPC uncertainties in both Tier 1 and 2 evaluations. Under both Tier 1 and Tier 2 evaluations, lack of coverage in some inaccessible areas affects the dose and risk characterization of those areas, as well as property-wide dose and risk characterization. As an example, most of the inaccessible soil data used for the Plant 6 HHRA, exist at the southwestern corner and western boundary (i.e., Hall Street). Little sample coverage was achieved beneath existing buildings/structures in the eastern portion of the property (Plant 6E). Therefore, the EPC calculated for all inaccessible areas (collectively) at Plant 6 will mainly reflect the western and southwestern portions of the property. This results in an overestimated inaccessible soil area fraction for calculation of the area-weighted average of the combined inaccessible/accessible EPC for the property, which in turn, results in an overestimation of actual dose and risk for Plant 6.

When performing Tier 2 calculations of inaccessible and accessible soil area fractions for each property with and existing PRAR/FSSE, the size of the accessible area used is the area established by the combined survey unit areas presented in the PRAR/FSSE. Because some survey units overlap with the property boundary, and may include samples outside of the property boundary, the size of the combined accessible area for the property could be overestimated. This results in the estimated size of inaccessible area (calculated as the difference between the total property area and the PRAR accessible area) as being slightly underestimated. The actual impacts to dose and risk estimation as a result of overestimated accessible area fractions, along with the inclusion of sample locations just outside of the property boundary, vary with each property and are dependent on other factors such as sample coverage and the presence of hotspots. For properties without a PRAR/FSSE, accessible and inaccessible areas were both estimated. Generally, the overall inaccessible area for a property was estimated based on RI sample coverage, and the overall accessible area was generally calculated to be the difference between the total property area and the estimated inaccessible area. This could result in either an over-or underestimation of dose and risk results, and could be subject to change as additional future actions may be conducted at those properties. All uncertainties associated with property-wide evaluations will become minimized in the FS, as thc focus becomes more the evaluations of individual elevated measurement areas, including those areas beneath buildings, that are driving overall property dose and risk.

Analytical results are used to calculate a mean concentration and the 95% UCL on the mean concentration. The lesser of the maximum detected concentration and the 95% UCL was used as the EPC for the HHRA. For the data sets containing a small number of samples results with high standard deviation, e.g., many elevated measurement areas, the maximum detection was used, thereby representing a worst-case scenario. Therefore, doses and risks generated for elevated measurement areas are likely to have been overestimated.

Generally, moderate uncertainty can be introduced in the data aggregation process for estimating a representative EPC. USEPA's ProUCL program applied statistical tests to determine the distribution that best describes the dataset for each chemical within each area of concern. For each COPC, ProUCL then reports the 95% UCL associated with the distribution type that best describes the dataset of interest. In many instances, 95% UCLs are calculated using both detected values and one-half the reported detection limit for samples without a detected concentration. The EPC was determined to be the lesser of the maximum detected concentration versus the calculated 95% UCL. This method may moderately overestimate the exposure concentration. In addition, when the resulting individual contaminant risks are summed to provide a total CR or HI, the compounding conservatism of this method for estimating EPCs likely has resulted in an overestimation of the total risk.

Additionally, it is conservatively assumed that chemical concentrations detected under current site conditions will remain constant for evaluations of future exposure scenarios. In other words, the measured concentrations (and resulting EPCs) are not reduced by loss due to natural removal processes such as volatilization, leaching, and/or biodegradation. This assumption is a source of uncertainty that tends to overestimate future exposure concentrations.

#### *K2.6.4.2 Exposure Assumptions*

For each exposure pathway chosen for analysis in the HHRA, assumptions are made concerning the exposure parameters (e.g., amount of contaminated media a receptor can be exposed to and intake rates for different routes of exposure) and the routes of exposure. In the absence of site-specific data, the assumptions used are consistent with USEPA-approved default values, which are assumed to be representative of potentially exposed populations. However, in some cases, rather than apply default values, professional judgment was applied to allow for more realistic estimates. Examples of this are the exposure frequencies of 10 days for the duration of a small project involving utility work, and the assumption that a sewer maintenance worker will only work at each location one day per year.

For RESRAD evaluations, exposure parameters were selected to provide a conservative yet reasonable estimate of potential risks to each receptor. Site-specific measurements and data were used, as appropriate, to describe site conditions as accurately as possible. Where site-specific data were not available, parameter values recommended by the Exposure Factors Handbook (USEPA 1997a) were chosen to provide reasonably conservative estimates of risk, or standard default values were used. For all scenarios, the RESRAD model assumes that contamination is always uniformly spread over the area assessed and is never covered in either the inaccessible or accessible soil areas. Assuming no cover over the contaminated zone, while applying the most reasonably maximum exposure scenario (i.e., the industrial worker) allows for a consistent assessment of dose and risk across all areas, and provides a starting point for the dose and risk-based evaluations in the FS to support development of remedial alternatives.

For the outdoor building occupancy scenario, actual areas of elevated activity were spotty, small, and non-removable compared to the uniform partially removable contaminated area assumed in the model. Inhalation, the primary pathway for risk for the building occupancy scenario, is dependent on the level of removable contamination. Assuming a higher than actual level of removable contamination will result in over-estimating risk. Additionally for this scenario, gross alpha survey data were multiplied by SLDS COC activity fractions to get individual COC concentration values needed by the model to estimate risk. This assumes that COC contamination on structures, if MED/AEC-related, was at the same fraction of activity as that found in the soil. Because individual COC SFs vary, actual risk may vary depending on actual activity fractions.

The accuracy of exposure calculations is ultimately limited to the accuracy of the site data and RESRAD models. The data used in the assessment include results from several characterization efforts and include different target analytes, analysis methods, and reporting requirements. The data in this assessment are used assuming the best knowledge of the distribution of contaminants in site soil with the goal of providing conservative yet reasonable estimates of risk. The models used to calculate risks and doses are approved by USEPA and are assumed to provide a reasonable prediction of site exposures.

### K2.6.5 Toxicity Assessment

Uncertainties are inherent in the SFs and IURs used to determine CRs for both radiological and metal COPCs, as well as for RfDs and RfCs used to determine HIs for metal COPCs.

#### *K2.6.5.1 Toxicity Assessment for Radiological Contaminants of Potential Concern*

In October 1999, Washington State University, under contract to USACE, published a report titled *Determination of the In Vitro Dissolution Rates of Selected Radionuclides in Soil and*

*Subsequent ICRP 30 Solubility Classification for Dosimetry* (WSU 1999) that may be used to support radiological dose and risk estimates. In vitro dissolution rates are broken into three classes: D, W, and Y (day, week, and year). Class D, W, and Y refer to retention time in the respiratory system and not necessarily retention time/exposure to the target organ. Sometimes the Class D or W are more limiting than the Class Y. RESRAD only uses the class Y dose conversion factor for the three uranium isotopes. Generally, RESRAD uses the most limiting dose conversion factor DCF (whether its Class D, W, or Y) for all COPCs.

Lifetime CR estimates are provided for exposure to chemical contaminants and are compared to the lower boundary of the CERCLA target risk range of 1.0E-06 to 1.0E-04. Radiological risk SFs have been developed primarily using data from groups such as the Japanese atomic bomb survivors. These individuals received large doses of radiation over a short period of time. By contrast, potential receptors in this assessment receive relatively small radiological doses over a long period of time. Although cancerous effects have only been detected at doses several orders of magnitude larger than those estimated at the SLDS, it is assumed that the SFs apply to both large and small radiological doses. Metal SFs are developed mostly from animal studies, and SFs for radionuclides and metal constituents incorporate several differences that may result in incompatibility. USEPA, therefore, acknowledges a large (undefined) uncertainty in risk estimates and recommends that radiological and metal risks be presented separately (USEPA 1996b).

A series of reports published by the National Research Council's Committee on the Biological Effects of Ionizing Radiation lists additional uncertainties resulting from the use of CSFs for radionuclides. The National Research Council's Committee on the Biological Effects of Ionizing Radiation reports point out that CRs from exposure to radionuclides at environmental levels (typical background radiation produces approximately 300 mrem/yr) are very difficult to distinguish from background cancer rates. In addition, the calculations of SFs are based on radium dial painter studies, atomic bomb survivor studies, etc., each considering doses many orders of magnitude higher than those received at environmental levels. The applicability of the linear no-threshold model has been debated by many professional societies. However, the linear no-threshold model (i.e., assuming risk is linear with exposure and is possible for even the smallest doses) has been adopted by all relevant United States regulating agencies. Using this model, risks at environmental levels are calculated even at dose levels a small fraction of background.

#### *K2.6.5.2 Toxicity Assessment for Metal Contaminants of Potential Concern*

The methodology used to develop a non-carcinogenic toxicity value (RfD or RfC) involves identifying a threshold level below which adverse health effects are not expected to occur. The RfD and RfC values are generally based on studies of the most sensitive animal species tested (unless adequate human data are available) and the most sensitive endpoint measured. Uncertainties exist in the experimental dataset for such animal studies. These studies are used to derive the experimental exposure representing the highest dose level tested at which no NOAEL is demonstrated; however, only a LOAEL is available. The RfD and/or RfC is derived from the NOAEL (or LOAEL) for the critical toxic effect by dividing the NOAEL (or LOAEL) by uncertainty factors. These factors usually are in multipliers of 10, with each factor representing a specific area of uncertainty in the extrapolation of the data. For example, an uncertainty factor of 100 is typically used when extrapolating animal studies to humans. Additional uncertainty factors are sometimes necessary when other experimental data limitations are found. Because of the large uncertainties (10 to 10,000) associated with some RfD or RfC toxicity values, exact safe levels of exposure for humans are not known. For non-carcinogenic effects, the amount of human variability in physical characteristics is important in determining the risks that can be expected at low exposures and in determining the NOAEL (USEPA 1989a).

The toxicological data (SFs and RfDs) for dose-response relationships of metals are frequently updated and revised, which can lead to over- or underestimation of risks. These values are often extrapolations from animals to humans and this can also cause uncertainties in toxicity values because differences can exist in metal absorption, metabolism, excretion, and toxic response between animals and humans.

USEPA considers differences in body weight, surface area, and pharmacokinetic relationships between animals and humans to minimize the potential to underestimate the dose-response relationship; as a result, more conservatism is usually incorporated into these steps. In particular, toxicity factors that have high uncertainties may change as new information is evaluated. Therefore, COPCs associated with high uncertainties in toxicity studies may be subject to regulatory change in the future. Finally, the toxicity of a contaminant may vary significantly with the metal form present in the exposure medium. For example, risks from metals may be overestimated because they are conservatively assumed to be in their most toxic forms.

The carcinogenic potential of a metal can be estimated through a two-part evaluation involving: (1) a weight-of-evidence assessment to determine the likelihood that a metal is a human carcinogen, and (2) a SF assessment to determine the quantitative dose-response relationship. Uncertainties occur with both assessments. Chemicals fall into one of five groups on the basis of weight-of-evidence studies of humans and laboratory animals (USEPA 2005): (1) Group A – known human carcinogen; (2) Group B – probable human carcinogen based on limited human data or sufficient evidence in animals, but inadequate or no evidence in humans; (3) Group C – possible human carcinogens; (4) Group D – not classified as to human carcinogenicity; and (5) Group E – evidence of no carcinogenic effects in humans.

The SF for a metal is a plausible upper-bound estimate of the probability of a response per unit intake of a metal over a lifetime. It is used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. The SF is derived by applying a mathematical model to extrapolate from a relatively high, administered dose to animals to the lower exposure levels expected for humans. The SF represents the 95% UCL on the linear component of the slope (generally the low-dose region) of the tumorigenic dose-response curve. A number of low-dose extrapolation models have been developed and USEPA generally uses the linearized multi-stage model in the absence of adequate information to support other models. Therefore, methods used to derive SFs result in an overestimation of CRs in the HHRA.

### K2.6.6 Risk Characterization

Uncertainties inherent in the risk characterization reflect the uncertainties inherent in all risk assessment elements leading up to the calculation of doses, CRs, and HIs. Uncertainties specific to the risk characterization of ISOU media are discussed below.

#### *K2.6.6.1 Summation of Cancer Risks Across Radiological and Metal Contaminants of Potential Concern*

Doses and CRs were estimated for both radiological and metal COPCs in inaccessible soil (only metals were evaluated in sewer sediment) and gross alpha activity was evaluated for building surfaces. In areas where both radiological and metal CRs were estimated for inaccessible soil (sewer borehole locations and DT-9), the radiological and metal CRs are presented separately and were not summed together for the purpose of determining a total cumulative CR. USEPA's RAGS Part A (1989a) cautions against combining radiological and chemical risks because the derivations of SFs for radionuclides and metals are specific to distinct models incorporating different assumptions. USEPA (1996b) outlines these differences in the Radiation Exposure and Risk Assessment Manual. The major differences include the following:

- The radiological endpoint is fatal cancer – the endpoint for metals exposures is tumorigenic cancer or non-carcinogenic risk.
- Radiological risk estimates are based primarily on human data – metals risk estimates are based primarily on animal studies.
- Radiological risk estimates are based on the central estimate of the mean – metals risk estimates are based on 95% UCL of the mean.

Additionally, natural background radiation is ubiquitous at levels exceeding typical risk targets and natural variability may preclude the ability to quantify small incremental risks due to contamination (USEPA 1996b). Therefore, risks calculated for radionuclides and metals were assessed separately and not summed together for the estimation of cumulative CRs.

*K2.6.6.2 Summation of Non-carcinogenic Hazard Indices*

Uncertainties related to the summation of HQs and CRs across chemicals and pathways are generally a primary uncertainty in the risk characterization. In the absence of information on the toxicity of specific chemical mixtures, it is assumed that CRs and HQs are additive (i.e., cumulative) (USEPA 1989a). The limitations of this approach for non-carcinogens are: (1) the effects of a mixture of chemicals are generally unknown – it is possible that the interactions could be synergistic, antagonistic, or additive; (2) the RfDs have different accuracy and precision and are not based on the same severity or effect; and (3) HQ or intake summation is most properly applied to compounds that induce the same effects by the same mechanism. Therefore, the potential for occurrence of non-carcinogenic effects can be overestimated for chemicals that act by different mechanisms and on different target organs. In the HHRA, the identified metal COPCs exhibiting carcinogenic effects were arsenic and cadmium. Table 6-12G shows that these metals affect different target organs and induce different systemic effects; therefore, summation results in an overestimation of the HIs calculated for each receptor. However, the summation of these metals was only conducted for the evaluation of maintenance worker exposures to sewer sediment at Plant 1 (location SLD123489) along Salisbury Street and for the evaluation of sewer utility worker exposures to inaccessible soil adjacent to a sewer line at Plant 1 (borehole location SLD124540). In both cases, both the individual HIs estimated for each metal and the total HIs summed across both metals were well below USEPA's target value of 1.0. Had the total HI exceeded 1.0, additional target organ evaluations would have been required for estimating non-carcinogenic effects. However, because the total HI was less than 1.0, no further evaluations were necessary.

*K2.6.6.3 Risk Characterization of Lead Detected in Sewer Soil Boreholes*

Lead concentrations were detected at several sewer soil locations at Plants 1, 2, and 6W that exceed the 800-mg/kg industrial screening level. However, because of the unique toxicological properties of lead, risk is not quantitatively evaluated for this COPC, as was discussed in Section 6.4.2.5. Therefore, the exceedance of the industrial screening level indicates the potential for health risks to future construction workers exposed to lead in inaccessible soil at the aforementioned locations. The industrial screening level for the ISOU RI is USEPA's (2011a) RSL and was derived by USEPA using the ALM model, which assumes lead exposures to a pregnant female worker and fetus. The 800-mg/kg screening level corresponds to USEPA's 5% benchmark probability of exceeding a fetal blood lead level of 10 μg/dL. USEPA considers this benchmark to be protective of a fetus carried by a pregnant worker. It is assumed that a screening level protective of a fetus will also afford protection for male and female adult workers. Therefore, although CRs or HIs are not estimated for soil lead exposures to a construction worker working adjacent to sewers, application of the industrial screening level does not result in an underestimation of risks to this receptor.

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# K3.0 ECOLOGICAL ASSESSMENT

A comprehensive ecological risk assessment was not performed as part of this BRA. However, an environmental assessment of biota was previously conducted as part of the 1993 BRA (DOE 1993) to qualitatively evaluate potential ecological effects from contamination of primarily accessible environmental media at the SLS, which included the SLDS. The 1993 environmental assessment of biota was conducted after USEPA's (1989b) RAGS Volume 2 was published and prior to the publication of the currently used USEPA ecological risk guidance document entitled *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final* (USEPA 1997c). Therefore, the 1993 environmental assessment of biota primarily followed and cited ecological evaluation guidelines set forth in RAGS Volume 2 (1989b) as an established reference under the Superfund program. Currently, both guidance documents are typically used and cited during developments of ecological risk assessment.

## K3.1 PRE- AND POST-1993 ECOLOGICAL RISK ASSESSMENT GUIDANCE

RAGS Volume 2 provides conceptual guidance in planning ecological assessments to evaluate potential impacts to environmental resources at or near a hazardous waste site and outlines the following main components for defining the scope and design of an ecological assessment:

- determination of the objectives and level of effort appropriate to the site and site contaminants;
- evaluation of site characteristics;
- evaluation of COCs (e.g., determination of biological and environmental concentrations and evaluations of toxicity characteristics through literature research or laboratory studies);
- determination of exposures [includes determination of organisms that could be exposed, complete exposure pathways, frequency and duration of exposures, environmental factors (e.g., seasonal and climactic variations and site geophysical and contaminant features) that could influence exposures, receptor behavioral and metabolic characteristics, and contaminant bioavailability]; and
- selection of assessment endpoints, measurement endpoints, and ecological endpoints.

The risk characterizations formerly prepared under RAGS Volume 2 followed a semi-quantitative process of summarizing the following types of risk-related information regarding the site:

- contaminant concentrations in environmental media;
- contaminant concentrations in biota;
- toxicity test results;
- literature reviews of toxicity;
- field surveys of receptor populations, including sensitive and T&E species; and
- measures of community structure and ecosystem function.

Much of the risk characterization process under RAGS Volume 2 relied on weight-of-evidence judgments made regarding evaluations of the above items relative to whether or not adverse effects could actually be occurring to identified receptors.

Many of the above evaluations established under USEPA's (1989b) RAGS Volume 2 are also part of the current guidance. However, the current guidance provides more structure to the original process by employing a step-by-step ecological risk assessment approach. Many of the methods and definitions presented in the current ERAGS (1997c) are consistent with those in RAGS Volume 2 (1989b). Another difference between guidance documents is that the current ERAGS applies a quantitative approach toward calculating risk that determines an ecological HQ. The HQ is expressed as the ratio of the potential exposure (e.g., environmental concentration or dose) to a NOAEL or LOAEL. As was the case with RAGS Volume 2 (1989b), weight-of-evidence information is still used in determining if impacts to receptors are actually occurring.

## K3.2 1993 ECOLOGICAL ASSESSMENT OF BIOTA

Although no field/laboratory investigations were conducted to determine the cxtent to which biota had been affected from past MED/AEC operations at the SLDS [a component in both USEPA's RAGS Volume 2 (1989b) and ERAGS (1997c)] and no quantitative risk characterizations had been performed [per USEPA's ERAGS (1997c)], the 1993 environmental assessment of biota was conducted using methods common to both guides. Evaluations primarily consisted of comparisons of contaminant concentrations reported for accessible environmental media with toxicity-based radiological and chemical threshold values available in literature. These comparisons were conducted in conjunction with in-depth toxicity assessments of radiological and chemical contaminants identified during 1993 BRA and evaluations of other weights-of-evidence (e.g., actual contaminant fate and transport characteristics, exposure pathways, site characteristics, receptor characteristics, etc.) to assess if significant adverse ecological effects could be occurring at the SLDS.

The 1993 environmental assessment of biota concluded that due to the urban environment, limited wildlife habitat, and biotic diversity, the significance of the SLDS in regard to ecological resources is minimal, and stated the following:

> *"...the significance of the St. Louis Site with regard to ecological resources is minimal, and intensive field analysis for possible impacts to biota from site contaminants is not warranted. Therefore, future efforts should emphasize concerns that related to human health effects, especially because radiological risks at the St. Louis Site are generally higher than chemical risks to humans by one order of magnitude"* (DOE 1993).

Given the environmental setting/nature of ISOU media, USACE concurs with the findings of the 1993 ecological evaluation that potential impacts to ecological receptors from accessible environmental media at the SLDS are likely to be insignificant, because the SLDS is a heavily urbanized area not suitable for habitation of sensitive and T&E species. Therefore, potential impacts from ISOU media are likely to be even less significant than impacts from accessible media for the following reasons: (1) it is highly unlikely that potential ecological impacts from the ISOU are greater than those from accessible media, (2) the potential for direct exposures to ISOU media is greater for humans than for terrestrial or aquatic species, and (3) the potential for subsurface migration beneath structures to sensitive terrestrial or aquatic habitats (although none are likely to exist) is unlikely. Also, given that some remediation at the SLDS has since been conducted, potential impacts to ecological resources from the ISOU contaminated media are likely to be even less significant than those determined during the 1993 BRA. It is for the aforementioned reasons that the ISOU BRA does not include a comprehensive ecological risk assessment.

## K3.3 INACCESSIBLE SOIL OPERABLE UNIT ENVIRONMENTAL CONDITIONS

Although no comprehensive ecological risk assessment was performed as part of the ISOU RI, a site visit was conducted on September 10, 2010, to gather information necessary for completing USEPA's Ecological Checklist (see Appendix R) regarding current environmental conditions at the ISOU relative to potential receptors.

### K3.3.1 Environmental Setting

The basis for the evaluation is the Checklist for Ecological Assessment/Sampling contained in Appendix P, which provides further details on the environmental setting, as well as the contaminant fate and transport and exposure pathways. The SLDS is located in downtown St. Louis, Missouri, in an industrial land use area located to the north of the city's center. The ground surface across the site is relatively flat, with a surface elevation of about 430 ft amsl in the southwestern part of the site to 420 ft amsl near the Mississippi River. The SLDS has been continuously occupied since the 1800's and contains a number of industrial facilities. These facilities include the former Mallinckrodt facilities used in the production of nuclear fuel, a large metal recycling facility, a salt production facility, and several railway lines. The entire site is highly disturbed with areas containing several feet of fill material common throughout the site. A 500-year levee and floodwall separate the Mississippi River and the St. Louis Riverfront Trail from the industrial portions of the site.

Vegetation in the site is typical of highly disturbed urban areas and includes several noxious weeds such as Johnson grass, common ragweed, black locust, and tree of heaven. Other vegetation observed at the site include annual and perennial weed species such as common sunflowers, spotted spurge, foxtail, bush honeysuckle, Japanese honeysuckle, and mulberry. The Checklist for Ecological Assessment/Sampling in Appendix P provides further details on the environmental setting.

There is no surface water or sediment present at the site. Any drainage from the SLDS (rainwater, base-generated, etc.) is directed by combined sanitary and sewer lines off-site to the MSD Treatment Plant.

There is no natural ecological habitat at the site. There are buildings, roads, sidewalks, and parking lots in active use, along with strips of disturbance-tolerant vegetation. The limited vegetation, lack of suitable cover, and high level of disturbance is unattractive to wildlife. Only the hardiest urban receptor would use the site. No federal or Missouri T&E species exist at the SLDS.

### K3.3.2 Contaminant Fate and Transport

The primary COCs at the SLDS are radionuclides and metals. As discussed in Section 4.0, exceedances of human health screening levels were noted for inaccessible soil, sewer sediment, and building surfaces within the ISOU. However, the majority of the inaccessible soil is located in portions of the site that are paved, underneath facilities, or are otherwise generally inaccessible. Because the soil contamination is located in areas below paved surfaces, the surface processes, including volatilization, fugitive dust, erosion, runoff, and leaching, are insignificant mechanisms for transport of contamination at the site to ecological receptors. In addition, there are no sensitive or unique ecological receptors located within the site. Site concentrations were not compared to ecological screening levels because there are no complete and significant exposure pathways.

There are no significant migration pathways for sediment in sewer lines, except through possible leaks or breaks in the lines, which could result in impact to adjacent and underlying soil. However, this soil is inaccessible to sensitive ecological receptors and not expected to result in adverse effects.

Radiological contamination on exterior building surfaces has been determined to be fixed, with no potential for removal via natural weathering processes; therefore, there is no likelihood for impacts to ecological receptors.

Ground water at the SLDS is generally encountered around 7 to 32 ft bgs depending on the location within the site. Ecological receptors are, therefore, not directly exposed to groundwater at the SLDS. Migration of ground water to surface water cannot occur at the SLDS because there are no streams, ponds, or surface water bodies at the site. The potential for ground-water transport of significant levels of contaminants from ISOU media to the nearest surface water body, the Mississippi River, located adjacent to the site, appears extremely limited.

### K3.3.3 Conclusions Regarding Ecological Exposure Pathways

Given the information discussed above, and based on the results noted in the Ecological Checklist in Appendix R, it is concluded that there are no complete or significant exposure pathways for ecological receptors at the ISOU. For the ISOU, there are four factors that support the absence of exposure pathways. First, the majority of the site is covered by sidewalks, roads, buildings, and parking lot, which inhibit contaminant mobility, especially in the subsurface. Second, those areas not covered by sidewalks, roads, buildings, and parking lots have dense vegetative cover. Third, no unique or sensitive terrestrial receptors are likely to inhabit the SLDS due to the lack of suitable habitat for all but the most urban adapted species. Finally, most of the samples collected from ISOU media were collected from areas of the site not readily accessible to wildlife, further limiting direct contact between contaminants and ecological receptors

# K4.0 SUMMARY OF THE BASELINE RISK ASSESSMENT

A BRA was performed to estimate current and potential future dose and risks to human and ecological receptors that could result from exposures to radiological and metals COPCs in inaccessible soil and sewer sediment that were not addressed in the 1998 ROD (USACE 1998a). The BRA consists primarily of two components: a quantitative HHRA and a qualitative Ecological Assessment, the summaries and findings of which are discussed below.

## K4.1 HUMAN HEALTH RISK ASSESSMENT

The BRA was completed assuming no remedial actions would be completed and no institutional or engineering controls would be maintained or established. The HHRA identified ISOU media and site properties that exhibit dose and/or risk exceeding target criteria of 25 mrem/yr and a CR of 1 in 100,000 (1.0E-05), assuming the inaccessible soils become accessible. Risk-driver COPCs resulting in exceedances of target dose or risk criteria are identified as COCs for the FS.

Those COPCs that individually exceed target criteria were identified as COCs for evaluation in the FS. None of the exterior building surfaces or sediments in sewer lines exceeded dose or risk criteria and are therefore not retained for further evaluation in the FS. Based on the HHRA results, the following are properties/areas, potential human receptors, and COCs being retained for further evaluations in the FS.

*Inaccessible Soil at Plant Properties and Industrial/Commercial VPs:* The following properties exceeded dose/risk criteria for industrial worker evaluations:

- Plant 1 – Radiological COCs
- Plant 6 – Radiological COCs
- St. Louis City Property (DT-2) – Radiological COCs
- Gunther Salt (DT-4) North – Radiological COCs
- Heintz Steel (DT-6) – Radiological COCs

*Inaccessible Soil at Railroad Properties and Roadways:* The following properties exceeded risk criteria for industrial worker evaluations:

- *Railroad VPs:*
    - Norfolk Southern RR (DT-3) – Radiological COCs
    - Terminal RR (DT-9) Main Tracks – Radiological COCs
    - Terminal RR (DT-9) Rail Yard – Radiological COCs
    - Terminal RR Soil Spoils Area – Radiological COCs
    - BNSF RR (DT-12) – Radiological COCs and arsenic
- *Roadways:*
    - Hall Street (West of Plant 6) – Radiological COCs
    - North Second Street (West of Plant 1) – Radiological COCs
    - Mallinckrodt Street (North of Plant 2) – Radiological COCs
    - Destrehan Street (West of Hall Street) – Radiological COCs
    - Angelrodt Street (South of Plant 7S) – Radiological COCs

*Inaccessible Soil in Elevated Measurement Areas:* The following property exceeded dose/risk criteria for utility worker evaluations:

- Plant 1, Building 26 – Radiological COCs

*Inaccessible Soil Adjacent to Sewer Lines:* Several soil borings and soil samples associated with previous accessible sewer line excavations exceeded dose/risk criteria for sewer utility worker exposures to radiological COPCs in inaccessible soil adjacent to sewer lines. All CRs and HIs estimated for metal COPCs were below target criteria. However, lead was evaluated differently than other metals based on USEPA guidance. Lead is considered to be a COC in inaccessible soil areas near sewers at concentrations exceeding USEPA's industrial soil RSL of 800 mg/kg. Therefore, the following areas are being retained for further evaluation in the FS:

- Plant 1, Boreholes SLD124540 (Radiological COCs and Lead), SLD124560 (Lead), and SLD124570 (Lead)
- Plant 2, Borehole SLD124576 – Lead
- Plant 6, Sewer Line in Northwest Corner of Property, beneath Hall Street – Radiological COCs
- Plant 6, Borehole SLD127572 – Lead
- St. Louis City Property (DT-2), Sewer Beneath the Levee – Radiological COCs
- Plant 7N/BNSF RR (DT-12), Sewer Beneath the RR tracks – Radiological COCs

Because Plant 1 is not within the uranium-ore processing area, lead is not identified as a COC in boreholes SLD124540, SLD124560, and SLD124570.

## K4.2 ECOLOGICAL ASSESSMENT

A qualitative ecological assessment was conducted based on the environmental assessment of biota conducted for accessible media in the 1993 BRA (DOE 1993) and the findings of a September 10, 2010, site visit that documented the environmental setting, potential receptors, contaminant fate and transport, and exposure pathways per USEPA guidance (1997c). USACE concurs with the findings of the 1993 ecological evaluation that potential impacts to ecological receptors from ISOU media are likely to be insignificant. Given that some remediation at the SLDS has been conducted since 1993, potential impacts to ecological resources from the ISOU contaminated media are likely to be less significant than determined during the 1993 BRA. As a result of the qualitative ecological assessment findings, the ISOU BRA does not include a comprehensive ecological risk assessment.

# APPENDIX K

# FIGURE

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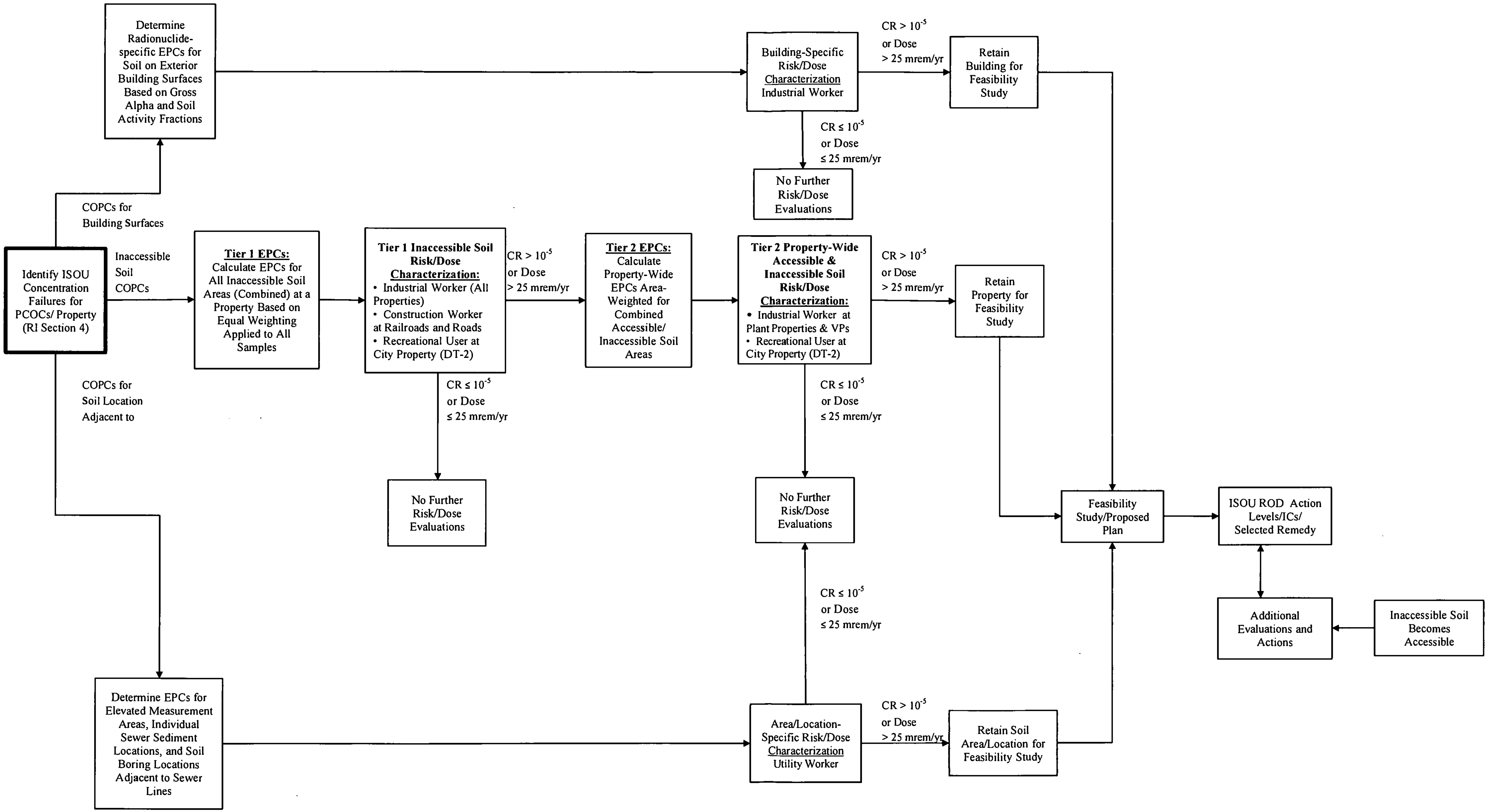


Figure K-1. ISOU Human Health Risk Assessment Process within CERCLA Framework

# APPENDIX K

# TABLES

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**Table K-1. Property and Media-Specific Receptor Scenarios for Evaluation in the Human Health Risk Assessment**

| Property | ISOU Media: | Inaccessible Soil (Assumed to be Accessible) | | | | Building/ Structural Surfaces | Sewers | |
|---|---|---|---|---|---|---|---|---|
| | Receptor: | Industrial Worker | Construction Worker | Utility Worker | Recreational User at City Property | Industrial Worker | Utility Worker (Soil Adjacent to Sewers) | Sewer Maintenance Worker (Sediment) |
| | Areas/Buildings Exceeding Screeing Levels (Section 4.0) | | | | | | | |
| Plant 1 | Building 25 | Radiological [a, b] | --- | Radiological [a] | --- | Radiological [a] | --- | --- |
| | Area Beneath Building 26 | | --- | Radiological [a] | --- | --- | --- | --- |
| | Two Areas Beneath Building X | | --- | Radiological [a] | --- | --- | --- | --- |
| | Four Areas at Building 8 | | --- | Radiological [a] | --- | --- | --- | --- |
| | Three Inaccessible Soil Areas Adjacent to Building K Excavation Area | | --- | Radiological [a] | --- | --- | --- | --- |
| | Inaccessible Soil Area North of Southeast Containment Pad | | --- | Radiological [a] | --- | --- | --- | --- |
| | Inaccessible Soil Area South of Building X Loading Dock | | --- | Radiological [a] | --- | --- | --- | --- |
| | Sewer Sediment Locations | --- | --- | --- | --- | --- | --- | As, Cd |
| | Sewer Borehole Between Buildings G and 17 | --- | --- | --- | --- | --- | Radiological, As, Cd, Pb | --- |
| Plant 2 | Building 508 | Radiological [a, b] | --- | Radiological [a] | --- | --- | --- | --- |
| | Area at North End of 50-Series Building Excavation | | --- | Radiological [a] | --- | --- | --- | --- |
| | Inaccessible Soil Area North of Building 510 (and South of the 50-Series Buildings Excavation). | | --- | Radiological [a] | --- | --- | --- | --- |
| | Southeast Corner | | --- | Radiological [a] | --- | --- | --- | --- |
| | Sewer Sediment Locations | --- | --- | --- | --- | --- | --- | As |
| | Sewer Borehole Locations | --- | --- | --- | --- | --- | Pb | --- |
| Plant 6 | Inaccessible Areas at the Southwest Corner Adjacent to Destrehan Street | Radiological [a, b] | --- | Radiological [a] | --- | --- | --- | --- |
| | Along Hall Street, West of Plant 6[c] | | | Radiological [a] | | | | --- |
| | Sewer Sediment Locations | --- | --- | --- | --- | --- | --- | As |
| | Sewer Beneath Hall Street at Northwest Corner of Plant 6WH | --- | --- | --- | --- | --- | Radiological [a] | --- |
| | Soil Location South of Plant 6W Adjacent to Sewer Line | | | | | | Pb | |
| City of St. Louis Property (DT-2) | Levee South Area (East of Adjacent Plant 7E and DT-1) | Radiological [a, b] | --- | Radiological [a] | Radiological [a, b] | --- | --- | --- |
| | Levee Area Just South of McKinley Bridge | | --- | Radiological [a] | | --- | --- | --- |
| | Sewers Beneath the Levee | --- | --- | --- | --- | --- | Radiological [a] | --- |

## Table K-1. Property and Media-Specific Receptor Scenarios for Evaluation in the Human Health Risk Assessment

| Property | ISOU Media: | Inaccessible Soil (Assumed to be Accessible) | | | | Building/ Structural Surfaces | Sewers | |
|---|---|---|---|---|---|---|---|---|
| | Receptor: / Areas/Buildings Exceeding Screeing Levels (Section 4.0) | Industrial Worker | Construction Worker | Utility Worker | Recreational User at City Property | Industrial Worker | Utility Worker (Soil Adjacent to Sewers) | Sewer Maintenance Worker (Sediment) |
| Gunther Salt North (DT-4) | Salt Dome Area and Northeast Corner of Southern Storage Building | Radiological [b, c] | --- | Radiological [a] | --- | --- | --- | --- |
| | Southern Storage Building | | --- | Radiological [a] | --- | --- | --- | --- |
| | Sidewalk along Buchanan Street | | --- | Radiological [a] | --- | --- | --- | --- |
| | Areas Within and Adjacent to Administration/Warehouse Building | | --- | Radiological [a] | --- | --- | --- | --- |
| Heintz Steel (DT-6) | Areas Beneath Storage Building | Radiological [a, b] | --- | Radiological [a] | --- | --- | --- | --- |
| | Inaccessible Area at Western Edge of Storage Building Along Hall Street | | --- | Radiological [a] | --- | --- | --- | --- |
| PSC Metals, Inc. (DT-8) | North Tract 3 – RR Tracks Area | Radiological [b, c] | --- | Radiological [a] | --- | --- | --- | --- |
| | North Tract 4 - RR Tracks Area | | --- | Radiological [a] | --- | --- | --- | --- |
| | South Tract – Southeast Corner of Warehouse | | --- | Radiological [a] | --- | --- | --- | --- |
| Thomas and Proetz Lumber Company (DT-10) | Property-Wide | As | --- | --- | --- | --- | --- | --- |
| | Wood Storage Building | --- | --- | --- | --- | Radiological [a] | | |
| | Office Building | --- | --- | As | --- | --- | --- | --- |
| McKinley Bridge (DT-11) | Sewer Sediment Locations | --- | --- | --- | --- | --- | --- | As |
| Cotto-Waxo Company (DT-14) | Horizontal Beam between L-Shaped Building and Brick Warehouse | --- | --- | --- | --- | Radiological [a] | --- | --- |
| Norfolk Southern RR (DT-3) | Elevated Measurement Areas between Mallinckrodt and Angelrodt Streets | Radiological [a, b] | Radiological [a, b] | Radiological [a, b] | --- | --- | --- | --- |
| Terminal RR Association (DT-9) Rail Yard | Three Areas in the Rail Yard (Two on the Northern RR Track and One on the RR Track Traversing Southwest to Northeast) | Radiological [a] | Radiological [a] | Radiological [a] | --- | --- | --- | --- |
| Terminal RR Association (DT-9) Main Tracks | Three Areas Between McKinley Bridge and Destrehan Street | Radiological, Cd [a] | Radiological, Cd [a] | Radiological, Cd [a] | --- | --- | --- | --- |
| Terminal RR Association Soil Spoils Area | Small Area at the Southern End of the Norfolk Southern RR Spur in the Northern Portion of the Property, and Two Isolated Areas Along the Terminal RR Tracks | Radiological [a] | Radiological [a] | Radiological [a] | --- | --- | --- | --- |
| BNSF RR (DT-12) | One Area North of McKinley Bridge, East and adjacent to DT-9 Rail Yard | Radiological, As [a, b] | Radiological, As [a, b] | Radiological, As [a, b] | --- | --- | --- | --- |
| | Large Area on the West side of Tracks Extending from Just North of Destrehan Street South to Dock Street | | | | --- | --- | --- | --- |
| | Sewers Northeast of Plant 7N that Extend Beneath BNSF RR tracks | --- | --- | --- | --- | --- | Radiological, Cd [a] | --- |

# Table K-1. Property and Media-Specific Receptor Scenarios for Evaluation in the Human Health Risk Assessment

| Property | ISOU Media: | Inaccessible Soil (Assumed to be Accessible) | | | | Building/ Structural Surfaces | Sewers | |
|---|---|---|---|---|---|---|---|---|
| | Receptor: | Industrial Worker | Construction Worker | Utility Worker | Recreational User at City Property | Industrial Worker | Utility Worker (Soil Adjacent to Sewers) | Sewer Maintenance Worker (Sediment) |
| | Areas/Buildings Exceeding Screeing Levels (Section 4.0) | | | | | | | |
| Hall Street | West of Plant 6[c] | Radiological [a] | Radiological [a] | Radiological [a] | --- | --- | --- | --- |
| North Second Street | West of Plant 1 | Radiological [a] | Radiological [a] | Radiological [a] | --- | --- | --- | --- |
| Mallinckrodt Street | North of Plant 2 | Radiological [a] | Radiological [a] | Radiological [a] | --- | --- | --- | --- |
| Destrehan Street | West of Hall Street | Radiological [a] | Radiological [a] | Radiological [a] | --- | --- | --- | --- |
| Angelrodt Street | South of Plant 7S | Radiological [a] | Radiological [a] | Radiological [a] | --- | --- | --- | --- |

Note: Receptor scenarios evaluated in this BRA and are the basis for determination of exposure point concentrations are shaded gray.

[a] Radiological COPCs were identified by exceedance of SORN > 1.0, and always include the following: Ac-227, Pa-231, Ra-226, radium-228 (Ra-228), thorium-228 (Th-228), Th-230, Th-232, U-235, and U-238. Metals were only identified as COPCs if they exceed the industrial risk-based screening level and are commingled with radiological contamination in at least one sampling location. Dashes indicate no COPCs are identified for the area and medium.

[b] Multiple specific locations are combined as shown into one property-wide exposure area for evaluation of dose and risk. Industrial/construction worker exposure areas are combined property-wide; utility worker exposure areas are combined to include areas around elevated locations.

[c] Elevated area on western border of Plant 6 is being evaluated for both Plant 6 and Hall Street.

"---" = No risk evaluation being performed for receptor at the identified property.

As - Arsenic

Cd - Cadmium

Pb - Lead

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**Table K-2A. Exposure Point Concentrations for Radiological Contaminants of Potential Concern Identified in Inaccessible Soil at Plant Properties and Industrial/Commercial Vicinity Properties: Industrial Worker**

| Property | Area ($m^2$) | Statistic (pCi/g) | Radiological COPC (pCi/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ac-227 | Pa-231 | Pb-210 [a] | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | U-234 [a] | U-235 | U-238 |
| Background [b] | | Mean | 0.14 | 0.90 | NA | 2.78 | 0.95 | 1.16 | 1.94 | 1.09 | NA | 0.08 | 1.44 |
| *Mallinckrodt Properties* | | | | | | | | | | | | | |
| Plant 1 | 10,500 | Maximum Detect | 22.10 | 27.70 | NA | 623.00 | 2.15 | 3.96 | 505.00 | 3.38 | NA | 17.40 | 316.00 |
| | | Distribution | X | X | NA | X | X | X | X | N | NA | X | X |
| | | 95% UCL | 1.32 | 1.27 | NA | 16.56 | 0.91 | 1.26 | 18.23 | 0.99 | NA | 1.28 | 23.97 |
| | | **EPC** | **1.18** | **0.37** | **17.91** | **13.78** | **0.00** | **0.10** | **16.29** | **0.00** | **22.53** | **1.20** | **22.53** |
| Plant 2 | 3,563 | Maximum Detect | 1.55 | 1.30 | NA | 12.20 | 13.10 | 16.30 | 11.00 | 12.30 | NA | 19.80 | 394.00 |
| | | Distribution | X | X | NA | X | X | X | X | X | NA | X | X |
| | | 95% UCL | 0.12 | 0.18 | NA | 2.26 | 1.12 | 1.57 | 3.22 | 1.28 | NA | 2.08 | 23.45 |
| | | **EPC** | **0.00** | **0.00** | **0.00** | **0.00** | **0.17** | **0.41** | **1.28** | **0.19** | **22.01** | **2.00** | **22.01** |
| Plant 6 | 2,370 | Maximum Detect | 13.50 | 14.80 | NA | 85.20 | 1.90 | 1.90 | 54.40 | 1.90 | NA | 95.40 | 1949.00 |
| | | Distribution | X | X | NA | X | N | N | X | N | NA | X | X |
| | | 95% UCL | 1.70 | 1.64 | NA | 10.27 | 0.83 | 1.06 | 10.81 | 0.99 | NA | 6.05 | 122.20 |
| | | **EPC** | **1.56** | **0.74** | **9.74** | **7.49** | **0.00** | **0.00** | **8.87** | **0.00** | **120.76** | **5.97** | **120.76** |
| *Industrial/Commercial Vicinity Properties* | | | | | | | | | | | | | |
| DT-2 (City Property) | 12,665 | Maximum Detect | 1.87 | 1.85 | NA | 66.40 | 1.79 | 2.64 | 11.00 | 2.51 | NA | 1.56 | 12.50 |
| | | Distribution | X | X | NA | X | X | X | X | N | NA | X | X |
| | | 95% UCL | 0.09 | 0.14 | NA | 4.36 | 0.96 | 1.23 | 2.84 | 1.07 | NA | 0.22 | 2.89 |
| | | **EPC** | **0.00** | **0.00** | **2.05** | **1.58** | **0.01** | **0.07** | **0.90** | **0.00** | **1.45** | **0.14** | **1.45** |
| DT-4 (Gunther Salt North) | 7,962 | Maximum Detect | 186.00 | 192.00 | NA | 137.00 | 2.35 | 3.06 | 1462.00 | 2.50 | NA | 81.30 | 1626.00 |
| | | Distribution | X | X | NA | X | X | X | X | X | NA | X | X |
| | | 95% UCL | 9.54 | 9.94 | NA | 9.62 | 1.07 | 1.39 | 65.42 | 1.23 | NA | 4.62 | 83.46 |
| | | **EPC** | **9.40** | **9.04** | **8.89** | **6.84** | **0.12** | **0.23** | **63.48** | **0.14** | **82.02** | **4.54** | **82.02** |
| DT-6 (Heintz Steel) | 3,582 | Maximum Detect | 151.00 | 160.00 | NA | 31.50 | 2.32 | 3.34 | 569.00 | 2.78 | NA | 13.77 | 244.74 |
| | | Distribution | X | X | NA | X | N | G | X | G | NA | X | X |
| | | 95% UCL | 6.86 | 7.19 | NA | 5.05 | 0.87 | 1.29 | 25.30 | 1.03 | NA | 1.54 | 26.11 |
| | | **EPC** | **6.72** | **6.29** | **2.95** | **2.27** | **0.00** | **0.13** | **23.36** | **0.00** | **24.67** | **1.46** | **24.67** |
| DT-8 (PSC Metals) | 19,614 | Maximum Detect | 1.21 | 3.11 | NA | 12.70 | 2.44 | 3.22 | 10.90 | 2.44 | NA | 1.19 | 21.40 |
| | | Distribution | X | X | NA | X | X | X | X | G | NA | X | X |
| | | 95% UCL | 0.12 | 0.15 | NA | 2.73 | 0.86 | 1.07 | 2.25 | 0.89 | NA | 0.20 | 3.27 |
| | | **EPC** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.31** | **0.00** | **1.83** | **0.12** | **1.83** |

[a] EPC was determined based upon table 2.15 of the Baseline Risk Assessment (DOE 1993)

[b] Background values were taken from Table 3-2 of the Background Soils Characterization Report for the St.Louis Downtown Site, St.Louis, Missouri (March 1999)

G - Data distribution is gamma.

X - Data distribution is neither normal, lognormal nor gamma.

NA - No Data Available or Not Applicable

## Table K-2B. Property-Wide Exposure Point Concentrations for Metal Contaminants of Potential Concern in Inaccessible Soil by Property: Industrial Worker

| Property | Location | Inaccessible Soil COPC | Maximum Detection (mgkg) | Location of Maximum Detection | 95% UCL (mg/kg) | Data Distribution Type | EPC (mg/kg) | Soil Background [a] (mg/kg) | Is EPC > Background? (Yes/No) |
|---|---|---|---|---|---|---|---|---|---|
| Terminal RR Main Tracks (DT-9) | Property-Wide | Cadmium | 69.3 | SLD124687 | 22.03 | Chebyshev | 22.03 | 1.03 | Yes |
| Thomas and Proetz Lumber (DT-10) | Property-Wide | Arsenic | 178 | SLD120307 | 162.5 | Gamma | 162.5 | 10.6 | Yes |
| BNSF RR (DT-12) | Property-Wide | Arsenic | 543 | SLD131212 | 166.80 | Gamma | 166.8 | 10.6 | Yes |

[a] Soil background value is the lesser of the 95% UCL and maximum detected concentration.

**Table K-3A. Exposure Point Concentrations for Radiological Contaminants of Potential Concern Identified in Inaccessible Soil at Railroads and Roadways: Industrial and Construction Workers**

| Property | Area ($m^2$) | Statistic (pCi/g) | Radiological COPC (pCi/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Ac-227** | **Pa-231** | **Pb-210** [a] | **Ra-226** | **Ra-228** | **Th-228** | **Th-230** | **Th-232** | **U-234** [a] | **U-235** | **U-238** |
| Background [b] | | Mean | 0.14 | 0.90 | NA | 2.78 | 0.95 | 1.16 | 1.94 | 1.09 | NA | 0.08 | 1.44 |
| ***Railroad Properties*** | | | | | | | | | | | | | |
| DT-3 (Norfolk Southern Railroad) | 6,363 | Maximum Detect | 4.16 | 6.30 | NA | 12.80 | 28.10 | 27.70 | 29.80 | 24.00 | NA | 2.12 | 42.70 |
| | | Distribution | X | X | NA | X | X | X | X | X | NA | X | X |
| | | 95% UCL | 0.12 | 0.16 | NA | 2.88 | 1.57 | 1.66 | 3.23 | 1.43 | NA | 0.27 | 4.32 |
| | | **EPC** | **0.00** | **0.00** | **0.13** | **0.10** | **0.62** | **0.50** | **1.29** | **0.34** | **2.88** | **0.19** | **2.88** |
| DT-9 (Terminal Railroad) Rail Yard | 24,384 | Maximum Detect | 13.80 | 17.90 | NA | 191.00 | 2.55 | 2.84 | 272.00 | 2.73 | NA | 12.30 | 177.00 |
| | | Distribution | X | X | NA | X | X | X | X | X | NA | X | X |
| | | 95% UCL | 0.53 | 0.66 | NA | 11.03 | 1.03 | 1.27 | 12.27 | 1.11 | NA | 0.67 | 10.16 |
| | | **EPC** | **0.39** | **0.00** | **10.73** | **8.25** | **0.08** | **0.11** | **10.33** | **0.02** | **8.72** | **0.59** | **8.72** |
| DT-9 (Terminal Railroad) Main Line | 36,630 | Maximum Detect | 1.10 | 4.23 | NA | 28.20 | 64.80 | 64.80 | 71.50 | 64.80 | NA | 1.41 | 14.30 |
| | | Distribution | X | X | NA | L | X | X | X | X | NA | X | X |
| | | 95% UCL | 0.08 | 0.17 | NA | 2.53 | 1.46 | 1.73 | 3.19 | 1.59 | NA | 0.16 | 2.43 |
| | | **EPC** | **0.00** | **0.00** | **0.00** | **0.00** | **0.51** | **0.57** | **1.25** | **0.50** | **0.99** | **0.08** | **0.99** |
| DT-9 (Terminal Railroad) Soil Spoils Area | 10,636 | Maximum Detect | 9.32 | 12.30 | NA | 16.90 | 2.60 | 2.60 | 260.00 | 2.60 | NA | 8.60 | 179.00 |
| | | Distribution | X | X | NA | X | G | N | X | X | NA | X | X |
| | | 95% UCL | 1.02 | 1.31 | NA | 4.33 | 0.80 | 1.05 | 30.13 | 0.86 | NA | 1.05 | 20.93 |
| | | **EPC** | **0.88** | **0.41** | **2.02** | **1.55** | **0.00** | **0.00** | **28.19** | **0.00** | **19.49** | **0.97** | **19.49** |
| DT-12 (BNSF) | 23,009 | Maximum Detect | 1.42 | 2.42 | NA | 8.95 | 1.80 | 2.86 | 53.90 | 1.74 | NA | 1.82 | 33.50 |
| | | Distribution | X | X | NA | X | N | N | X | N | NA | X | X |
| | | 95% UCL | 0.08 | 0.08 | NA | 2.27 | 0.67 | 0.88 | 4.59 | 0.76 | NA | 0.21 | 3.45 |
| | | **EPC** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **2.65** | **0.00** | **2.01** | **0.13** | **2.01** |

**Table K-3A. Exposure Point Concentrations for Radiological Contaminants of Potential Concern Identified in Inaccessible Soil at Railroads and Roadways: Industrial and Construction Workers**

| Property | Area ($m^2$) | Statistic (pCi/g) | Radiological COPC (pCi/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ac-227 | Pa-231 | Pb-210 [a] | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | U-234 [a] | U-235 | U-238 |
| ***Roadways*** | | | | | | | | | | | | | |
| Angelrodt Street | 6,127 | Maximum Detect | 0.89 | 2.88 | NA | 14.30 | 1.38 | 2.32 | 46.40 | 1.74 | NA | 0.79 | 9.33 |
| | | Distribution | X | X | NA | G | N | N | X | X | NA | N | X |
| | | 95% UCL | 0.14 | 0.38 | NA | 3.19 | 0.80 | 1.11 | 5.08 | 1.04 | NA | 0.16 | 3.04 |
| | | **EPC** | **0.00** | **0.00** | **0.53** | **0.41** | **0.00** | **0.00** | **3.14** | **0.00** | **1.60** | **0.08** | **1.60** |
| Destrehan Street | 5,622 | Maximum Detect | 2.26 | 4.23 | NA | 25.10 | 7.35 | 8.03 | 411.00 | 8.61 | NA | 4.48 | 75.90 |
| | | Distribution | X | X | NA | X | X | X | X | X | NA | X | X |
| | | 95% UCL | 0.12 | 0.15 | NA | 3.48 | 0.89 | 1.20 | 12.16 | 1.20 | NA | 0.37 | 7.10 |
| | | **EPC** | **0.00** | **0.00** | **0.91** | **0.70** | **0.00** | **0.04** | **10.22** | **0.11** | **5.66** | **0.29** | **5.66** |
| Hall Street | 2,274 | Maximum Detect | 14.60 | 15.00 | NA | 85.20 | 2.09 | 2.37 | 54.40 | 1.90 | NA | 9.48 | 190.00 |
| | | Distribution | X | X | NA | X | X | N | X | N | NA | X | X |
| | | 95% UCL | 0.78 | 0.81 | NA | 4.48 | 0.83 | 1.07 | 6.11 | 0.95 | NA | 0.50 | 8.42 |
| | | **EPC** | **0.64** | **0.00** | **2.21** | **1.70** | **0.00** | **0.00** | **4.17** | **0.00** | **6.98** | **0.42** | **6.98** |
| Mallinckrodt Street | 3,661 | Maximum Detect | 2.29 | 3.71 | NA | 3.93 | 1.70 | 3.95 | 13.90 | 3.39 | NA | 2.38 | 50.30 |
| | | Distribution | X | X | NA | L | N | X | L | X | NA | X | X |
| | | 95% UCL | 0.29 | 0.68 | NA | 1.62 | 0.80 | 1.40 | 2.54 | 1.31 | NA | 0.47 | 7.07 |
| | | **EPC** | **0.15** | **0.00** | **0.00** | **0.00** | **0.00** | **0.24** | **0.60** | **0.22** | **5.63** | **0.39** | **5.63** |
| North Second Street | 3,005 | Maximum Detect | 12.70 | 13.70 | NA | 10.30 | 1.44 | 1.95 | 27.10 | 1.73 | NA | 1.80 | 26.90 |
| | | Distribution | X | X | NA | L | N | N | X | N | NA | X | X |
| | | 95% UCL | 0.93 | 1.06 | NA | 2.62 | 0.83 | 1.11 | 4.68 | 1.00 | NA | 0.35 | 5.64 |
| | | **EPC** | **0.79** | **0.16** | **0.00** | **0.00** | **0.00** | **0.00** | **2.74** | **0.00** | **4.20** | **0.27** | **4.20** |

[a] EPC was determined based upon table 2.15 of the Baseline Risk Assessment (DOE 1993)

[b] Background values were taken from Table 3-2 of the Background Soils Characterization Report for the St.Louis Downtown Site, St. Louis, Missouri (March 1999)

L - Data distribution is lognormal.

N - Data distribution is normal.

X - Data distribution is neither normal, lognormal nor gamma.

NA - No Data Available or Not Applicable

## Table K-3B. Property-Wide Exposure Point Concentrations for Metal Contaminants of Potential Concern in Inaccessible Soil at Railroads: Construction Worker

| Property | Location | Inaccessible Soil COPC | Maximum Detection (mgkg) | Location of Maximum Detection | 95% UCL (mg/kg) | Data Distribution Type | EPC (mg/kg) | Soil Background [a] (mg/kg) | Is EPC > Background? (Yes/No) |
|---|---|---|---|---|---|---|---|---|---|
| Terminal RR (DT-9) | Main Tracks | Cadmium | 69.3 | SLD124687 | 22.03 | Chebyshev | 22.03 | 1.03 | Yes |
| DT-12 (BNSF Railroad) | Adjacent to Plants 6 and 7 | Arsenic | 543 | SLD131212 | 166.80 | Gamma | 166.8 | 10.6 | Yes |

[a] Soil background value is the lesser of the 95% UCL and maximum detected concentration.

**Table K-4A. Exposure Point Concentrations for Radiological Contaminants of Potential Concern Identified in Inaccessible Soil Elevated Measurement Areas by Property: Utility Worker**

| Property | Area (m²) | Statistic (pCi/g) | Radiological COPC (pCi/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ac-227 | Pa-231 | Pb-210 [a] | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | U-234 [a] | U-235 | U-238 |
| Background [b] | | Mean | 0.14 | 0.90 | NA | 2.78 | 0.95 | 1.16 | 1.94 | 1.09 | NA | 0.08 | 1.44 |
| *Mallinckrodt Properties* | | | | | | | | | | | | | |
| Plant 1 Building 8 | 440 | Maximum Detect | 22.10 | 27.70 | NA | 68.60 | 1.65 | 2.92 | 505.00 | 1.65 | NA | 8.55 | 151.00 |
| | | Distribution | X | X | NA | L | X | N | X | N | NA | X | L |
| | | 95% UCL | 3.82 | 4.29 | NA | 11.53 | 1.00 | 1.11 | 86.45 | 0.96 | NA | 1.76 | 19.19 |
| | | **EPC** | **3.68** | **3.39** | **11.38** | **8.75** | **0.05** | **0.00** | **84.51** | **0.00** | **17.75** | **1.68** | **17.75** |
| Plant 1 Building 26 | 173 | Maximum Detect | 21.70 | 12.60 | NA | 623.00 | 1.07 | 3.96 | 50.40 | 1.51 | NA | 1.33 | 9.43 |
| | | Distribution | X | X | NA | G | N | N | G | N | NA | N | X |
| | | 95% UCL | 9.67 | 5.94 | NA | 214.90 | 0.67 | 1.89 | 18.80 | 0.91 | NA | 0.58 | 12.73 |
| | | **EPC** | **9.53** | **5.04** | **275.76** | **212.12** | **0.00** | **0.73** | **16.86** | **0.00** | **7.99** | **0.50** | **7.99** |
| Plant 1 Building X | 1,226 | Maximum Detect | 20.80 | 22.80 | NA | 85.80 | 2.15 | 2.27 | 180.00 | 3.38 | NA | 17.40 | 301.00 |
| | | Distribution | X | X | NA | X | X | X | X | G | NA | X | X |
| | | 95% UCL | 3.83 | 4.18 | NA | 12.37 | 1.01 | 1.33 | 31.80 | 1.26 | NA | 2.77 | 46.84 |
| | | **EPC** | **3.69** | **3.28** | **12.47** | **9.59** | **0.06** | **0.17** | **29.86** | **0.17** | **45.40** | **2.69** | **45.40** |
| Plant 1 Building 25 | 823 | Maximum Detect | 0.73 | 1.75 | NA | 5.21 | 1.40 | 2.19 | 4.01 | 2.05 | NA | 14.90 | 307.00 |
| | | Distribution | X | X | NA | X | X | N | X | N | NA | X | X |
| | | 95% UCL | 0.31 | 0.43 | NA | 2.42 | 1.10 | 1.45 | 2.20 | 1.23 | NA | 2.14 | 43.75 |
| | | **EPC** | **0.17** | **0.00** | **0.00** | **0.00** | **0.15** | **0.29** | **0.26** | **0.14** | **42.31** | **2.06** | **42.31** |
| Plant 1 Building K Excavation | 193 | Maximum Detect | 0.73 | 0.97 | NA | 20.72 | 1.23 | 1.99 | 127.49 | 1.59 | NA | 12.90 | 238.00 |
| | | Distribution | N | N | NA | L | X | N | X | X | NA | X | X |
| | | 95% UCL | 0.35 | 0.30 | NA | 7.03 | 1.30 | 1.43 | 88.96 | 1.49 | NA | 6.26 | 186.30 |
| | | **EPC** | **0.21** | **0.00** | **5.53** | **4.25** | **0.28** | **0.27** | **87.02** | **0.40** | **184.86** | **6.18** | **184.86** |
| Plant 1 Loading Dock [c] | 67 | Maximum Detect | 0.62 | 0.23 | NA | 12.20 | 0.91 | 1.13 | 22.30 | 1.15 | NA | 0.67 | 3.65 |
| | | **EPC** | **0.48** | **0.00** | **12.25** | **9.42** | 0.00 | 0.00 | **20.36** | 0.06 | **2.21** | 0.59 | **2.21** |
| Plant 1 Southeast Containment Pad[3] | 135 | Maximum Detect | 3.01 | 0.47 | NA | 3.04 | 0.94 | 1.13 | 37.40 | 1.10 | NA | 5.85 | 110.00 |
| | | **EPC** | **2.87** | 0.00 | **0.34** | **0.26** | **0.00** | **0.00** | **35.46** | **0.01** | **108.56** | **5.77** | **108.56** |
| Plant 2 Building 508 [c] | 85 | Maximum Detect | 0.14 | 0.39 | NA | 1.84 | 0.94 | 1.49 | 7.01 | 1.28 | NA | 3.78 | 75.90 |
| | | **EPC** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.33** | **5.07** | 0.19 | **74.46** | **3.70** | **74.46** |
| Plant 2 50 Series Excavation North [c] | 32 | Maximum Detect | 1.55 | 0.31 | NA | 2.56 | 1.45 | 1.80 | 3.71 | 2.26 | NA | 19.80 | 394.00 |
| | | **EPC** | **1.41** | **0.00** | 0.00 | 0.00 | **0.50** | **0.64** | **1.77** | **1.17** | **392.56** | **19.72** | **392.56** |
| Plant 2 Inaccessible Soil Area North of Building 510 (and South of the 50-Series Buildings Excavation | 34 | Maximum Detect | 0.20 | 0.35 | NA | 1.87 | 1.08 | 1.34 | 1.86 | 1.15 | NA | 10.10 | 213.00 |
| | | Distribution | N | N | NA | N | N | N | X | N | NA | X | X |
| | | 95% UCL | 0.07 | 0.09 | NA | 1.38 | 0.61 | 0.90 | 15.79 | 0.77 | NA | 4.34 | 91.30 |
| | | **EPC** | **0.00** | **0.00** | 0.00 | **0.00** | 0.00 | 0.00 | **0.00** | **0.00** | **89.86** | **4.26** | **89.86** |
| Plant 2 Southeast Corner [c] | 15 | Maximum Detect | 0.28 | 0.58 | NA | 7.15 | 13.10 | 16.30 | 4.67 | 12.30 | NA | 0.41 | 3.82 |
| | | **EPC** | **0.14** | 0.00 | **5.68** | **4.37** | **12.15** | **15.14** | **2.73** | **11.21** | **2.38** | **0.33** | **2.38** |

**Table K-4A. Exposure Point Concentrations for Radiological Contaminants of Potential Concern Identified in Inaccessible Soil Elevated Measurement Areas by Property: Utility Worker**

| Property | Area ($m^2$) | Statistic (pCi/g) | Radiological COPC (pCi/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ac-227 | Pa-231 | Pb-210 [a] | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | U-234 [a] | U-235 | U-238 |
| Plant 6 Southwest Corner | 82 | Maximum Detect | 13.50 | 14.80 | NA | 57.30 | 1.34 | 1.50 | 44.80 | 1.80 | NA | 95.40 | 1949.00 |
| | | Distribution | X | X | NA | X | N | N | X | N | NA | X | L |
| | | 95% UCL | 4.52 | 4.51 | NA | 23.59 | 0.93 | 1.17 | 16.14 | 1.10 | NA | 28.97 | 1192.00 |
| | | **EPC** | **4.38** | **3.61** | **27.05** | **20.81** | **0.00** | **0.01** | **14.20** | **0.01** | **1190.56** | **28.89** | **1190.56** |
| Plant 6 Along Hall Street | 155 | Maximum Detect | 11.40 | 9.18 | NA | 85.20 | 1.90 | 1.90 | 54.40 | 1.90 | NA | 9.48 | 190.00 |
| | | Distribution | X | X | NA | L | N | N | X | N | NA | X | L |
| | | 95% UCL | 3.69 | 3.56 | NA | 12.22 | 0.97 | 1.13 | 25.22 | 1.15 | NA | 2.22 | 28.12 |
| | | **EPC** | **3.55** | **2.66** | **12.27** | **9.44** | **0.02** | **0.00** | **23.28** | **0.06** | **26.68** | **2.14** | **26.68** |
| ***Industrial/Commerical Vicinity Properties*** | | | | | | | | | | | | | |
| DT-2 (City Property) Levee South Area | 1,272 | Maximum Detect | 1.87 | 1.71 | NA | 66.40 | 1.66 | 2.64 | 11.00 | 2.15 | NA | 0.85 | 10.10 |
| | | Distribution | X | X | NA | X | X | N | X | N | NA | N | X |
| | | 95% UCL | 0.20 | 0.31 | NA | 8.57 | 1.11 | 1.53 | 3.82 | 1.25 | NA | 0.29 | 3.36 |
| | | **EPC** | **0.06** | **0.00** | **7.53** | **5.79** | **0.16** | **0.37** | **1.88** | **0.16** | **1.92** | **0.21** | **1.92** |
| DT-2 (City Property) Levee South of McKinley Bridge | 317 | Maximum Detect | 0.83 | 1.05 | NA | 21.70 | 1.11 | 2.18 | 9.18 | 1.73 | NA | 1.08 | 10.50 |
| | | Distribution | X | N | NA | X | X | N | X | N | NA | X | X |
| | | 95%UCL | 0.19 | 0.16 | NA | 6.04 | 0.92 | 1.24 | 3.36 | 1.09 | NA | 0.42 | 5.00 |
| | | **EPC** | **0.05** | **0.00** | **4.24** | **3.26** | **0.00** | **0.08** | **1.42** | **0.00** | **3.56** | **0.34** | **3.56** |
| DT-4 (Gunther Salt North) Salt Domes | 1,540 | Maximum Detect | 186.00 | 192.00 | NA | 87.10 | 2.35 | 2.35 | 1462.00 | 2.35 | NA | 81.30 | 1626.00 |
| | | Distribution | X | X | NA | X | N | N | X | N | NA | X | G |
| | | 95% UCL | 39.36 | 41.30 | NA | 17.87 | 1.46 | 1.61 | 280.80 | 1.56 | NA | 16.29 | 196.50 |
| | | **EPC** | **39.22** | **40.40** | **19.62** | **15.09** | **0.51** | **0.45** | **278.86** | **0.47** | **195.06** | **16.21** | **195.06** |
| DT-4 (Gunther Salt North) Sidewalk | 206 | Maximum Detect | 19.50 | 20.20 | NA | 8.44 | 1.43 | 1.91 | 44.30 | 1.92 | NA | 12.80 | 238.00 |
| | | Distribution | X | X | NA | G | N | N | X | N | NA | X | X |
| | | 95% UCL | 4.90 | 5.06 | NA | 5.06 | 0.99 | 1.39 | 14.74 | 1.27 | NA | 3.64 | 67.83 |
| | | **EPC** | **4.76** | **4.16** | **2.96** | **2.28** | **0.04** | **0.23** | **12.80** | **0.18** | **66.39** | **3.56** | **66.39** |
| DT-4 (Gunther Salt North) South Storage Building | 616 | Maximum Detect | 52.20 | 57.10 | NA | 137.00 | 1.29 | 3.06 | 74.80 | 1.83 | NA | 2.87 | 39.50 |
| | | Distribution | X | X | NA | X | N | G | X | N | NA | X | G |
| | | 95% UCL | 12.40 | 13.31 | NA | 42.51 | 0.93 | 1.60 | 24.17 | 1.15 | NA | 1.09 | 13.50 |
| | | **EPC** | **12.26** | **12.41** | **51.65** | **39.73** | **0.00** | **0.44** | **22.23** | **0.06** | **12.06** | **1.01** | **12.06** |
| DT-4 (Gunther Salt North) Admin/Warehouse Building | 4,606 | Maximum Detect | 16.90 | 16.30 | NA | 10.30 | 1.82 | 3.04 | 49.60 | 2.50 | NA | 29.40 | 560.00 |
| | | Distribution | X | X | NA | N | N | N | X | N | NA | X | X |
| | | 95% UCL | 1.68 | 1.72 | NA | 4.01 | 0.94 | 1.43 | 7.44 | 1.10 | NA | 3.24 | 61.39 |
| | | **EPC** | **1.54** | **0.82** | **1.60** | **1.23** | **0.00** | **0.27** | **5.50** | **0.01** | **59.95** | **3.16** | **59.95** |
| DT-6 (Heintz Steel) Western Edge of Storage Building | 96 | Maximum Detect | 19.56 | 20.94 | NA | 4.33 | 1.18 | 3.20 | 85.62 | 2.32 | NA | 13.77 | 244.74 |
| | | Distribution | X | X | NA | N | N | G | X | G | NA | G | G |
| | | 95% UCL | 8.74 | 9.04 | NA | 3.13 | 0.85 | 1.25 | 40.51 | 1.08 | NA | 5.11 | 82.28 |
| | | **EPC** | **8.60** | **8.14** | **0.46** | **0.35** | **0.00** | **0.09** | **38.57** | **0.00** | **80.84** | **5.03** | **80.84** |

**Table K-4A. Exposure Point Concentrations for Radiological Contaminants of Potential Concern Identified in Inaccessible Soil Elevated Measurement Areas by Property: Utility Worker**

| Property | Area ($m^2$) | Statistic (pCi/g) | Radiological COPC (pCi/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ac-227 | Pa-231 | Pb-210 [a] | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | U-234 [a] | U-235 | U-238 |
| DT-6 (Heintz Steel) Storage Building | 494 | Maximum Detect | 151.00 | 160.00 | NA | 31.50 | 1.34 | 2.19 | 569.00 | 1.62 | NA | 5.75 | 70.60 |
| | | Distribution | X | X | NA | X | N | N | X | N | NA | X | X |
| | | 95% UCL | 13.01 | 13.81 | NA | 6.74 | 0.92 | 1.34 | 52.32 | 1.03 | NA | 0.87 | 13.66 |
| | | **EPC** | **12.87** | **12.91** | **5.15** | **3.96** | **0.00** | **0.18** | **50.38** | **0.00** | **12.22** | **0.79** | **12.22** |
| DT-8 (PSC Metals, Inc.) SE corner of Warehouse | 1,030 | Maximum Detect | 0.50 | 3.11 | NA | 12.70 | 1.26 | 1.61 | 8.29 | 1.58 | NA | 0.50 | 19.40 |
| | | Distribution | X | X | NA | G | N | N | G | N | NA | N | L |
| | | 95% UCL | 0.26 | 1.12 | NA | 5.37 | 0.80 | 1.12 | 4.27 | 0.90 | NA | 0.22 | 6.86 |
| | | **EPC** | **0.12** | **0.22** | **3.37** | **2.59** | **0.00** | **0.00** | **2.33** | **0.00** | **5.42** | **0.14** | **5.42** |
| DT-8 (PSC Metals) RR Tracks Area 3 | 529 | Maximum Detect | 1.21 | 2.24 | NA | 4.81 | 1.31 | 1.34 | 10.10 | 1.34 | NA | 0.53 | 3.81 |
| | | Distribution | X | X | NA | N | N | N | X | N | NA | N | G |
| | | 95% UCL | 0.54 | 0.97 | NA | 2.67 | 0.95 | 1.01 | 6.02 | 0.99 | NA | 0.20 | 1.77 |
| | | **EPC** | **0.40** | **0.07** | **0.00** | **0.00** | **0.00** | **0.00** | **4.08** | **0.00** | **0.33** | **0.12** | **0.33** |
| DT-8 (PSC Metals) RR Tracks Area 4 | 212 | Maximum Detect | 0.27 | 0.85 | NA | 3.42 | 1.07 | 1.69 | 7.06 | 1.22 | NA | 0.55 | 6.49 |
| | | Distribution | N | N | NA | N | N | N | N | N | NA | N | N |
| | | 95% UCL | 0.19 | 0.31 | NA | 2.89 | 0.99 | 1.54 | 4.66 | 1.12 | NA | 0.33 | 4.39 |
| | | **EPC** | **0.05** | **0.00** | **0.14** | **0.11** | **0.04** | **0.38** | **2.72** | **0.03** | **2.95** | **0.25** | **2.95** |
| *Railroad Properties* | | | | | | | | | | | | | |
| DT-3 (Norfolk Southern Railroad) East of Plant 10 and btw Mallinkrodt and Destrehan | 662 | Maximum Detect | 4.16 | 6.30 | NA | 12.80 | 28.10 | 27.70 | 29.80 | 24.00 | NA | 2.12 | 42.70 |
| | | Distribution | X | X | NA | G | X | X | G | X | NA | X | G |
| | | 95% UCL | 0.66 | 1.03 | NA | 4.63 | 6.72 | 5.46 | 6.47 | 4.76 | NA | 0.71 | 8.92 |
| | | **EPC** | **0.52** | **0.13** | **2.41** | **1.85** | **5.77** | **4.30** | **4.53** | **3.67** | **7.48** | **0.63** | **7.48** |
| DT-12 (BNSF RR) North of Mckinley Bridge and west side of tracks | 7,156 | Maximum Detect | 0.84 | 1.42 | NA | 8.95 | 1.34 | 2.41 | 53.90 | 1.74 | NA | 1.82 | 33.50 |
| | | Distribution | X | X | NA | G | N | N | X | N | NA | X | L |
| | | 95% UCL | 0.14 | 0.14 | NA | 2.43 | 0.65 | 0.89 | 7.71 | 0.80 | NA | 0.30 | 4.35 |
| | | **EPC** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **5.77** | **0.00** | **2.91** | **0.22** | **2.91** |
| DT-9 (Terminal Railroad) Main Tracks | 191 | Maximum Detect | 1.10 | 0.99 | NA | 28.20 | 64.80 | 64.80 | 71.50 | 64.80 | NA | 1.41 | 13.20 |
| | | Distribution | X | N | NA | X | X | X | X | X | NA | X | G |
| | | 95% UCL | 0.35 | 0.17 | NA | 8.34 | 10.89 | 11.17 | 15.44 | 10.95 | NA | 0.36 | 3.00 |
| | | **EPC** | **0.21** | **0.00** | **7.23** | **5.56** | **9.94** | **10.01** | **13.50** | **9.86** | **1.56** | **0.28** | **1.56** |
| DT-9 (Terminal Railroad) Rail Yard | 5,244 | Maximum Detect | 13.80 | 17.90 | NA | 191.00 | 2.07 | 2.28 | 272.00 | 2.73 | NA | 12.30 | 177.00 |
| | | Distribution | X | X | NA | X | X | N | X | X | NA | X | X |
| | | 95% UCL | 2.21 | 2.32 | NA | 38.00 | 1.22 | 1.31 | 44.20 | 1.35 | NA | 2.29 | 34.91 |
| | | **EPC** | **2.07** | **1.42** | **45.79** | **35.22** | **0.27** | **0.15** | **42.26** | **0.26** | **33.47** | **2.21** | **33.47** |
| DT-9 (Terminal Railroad) Soil Spoils Area | 9,626 | Maximum Detect | 9.32 | 12.30 | NA | 16.90 | 2.60 | 2.60 | 260.00 | 2.60 | NA | 8.60 | 179.00 |
| | | Distribution | X | X | NA | G | G | N | X | G | NA | X | X |
| | | 95% UCL | 1.68 | 2.10 | NA | 4.38 | 0.98 | 1.21 | 48.28 | 1.04 | NA | 1.68 | 33.58 |
| | | **EPC** | **1.54** | **1.20** | **2.08** | **1.60** | **0.03** | **0.05** | **46.34** | **0.00** | **32.14** | **1.60** | **32.14** |

**Table K-4A. Exposure Point Concentrations for Radiological Contaminants of Potential Concern Identified in Inaccessible Soil Elevated Measurement Areas by Property: Utility Worker**

| Property | Area (m²) | Statistic (pCi/g) | Radiological COPC (pCi/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ac-227 | Pa-231 | Pb-210 [a] | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | U-234 [a] | U-235 | U-238 |
| *Roadways* | | | | | | | | | | | | | |
| Angelrodt Street | 548 | Maximum Detect | 0.27 | 0.37 | NA | 5.34 | 1.19 | 1.23 | 46.40 | 1.74 | NA | 0.39 | 4.84 |
| | | Distribution | N | N | NA | N | N | N | X | N | NA | N | N |
| | | 95% UCL | 0.14 | 0.09 | NA | 4.01 | 0.96 | 1.07 | 22.42 | 1.22 | NA | 0.22 | 3.43 |
| | | **EPC** | **0.00** | **0.00** | **1.60** | **1.23** | **0.01** | **0.00** | **20.48** | **0.13** | **1.99** | **0.14** | **1.99** |
| Destrehan Street | 873 | Maximum Detect | 0.37 | 1.51 | NA | 7.36 | 1.21 | 5.95 | 6.23 | 6.43 | NA | 1.80 | 35.70 |
| | | Distribution | X | X | NA | G | N | G | G | X | NA | X | X |
| | | 95% UCL | 0.14 | 0.47 | NA | 2.62 | 0.87 | 1.58 | 2.60 | 2.15 | NA | 0.55 | 10.09 |
| | | **EPC** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.42** | **0.66** | **1.06** | **8.65** | **0.47** | **8.65** |
| Hall Street | 549 | Maximum Detect | 14.60 | 15.00 | NA | 85.20 | 1.90 | 1.92 | 54.40 | 1.90 | NA | 9.48 | 190.00 |
| | | Distribution | X | X | NA | X | X | N | X | N | NA | X | X |
| | | 95% UCL | 1.34 | 1.40 | NA | 6.48 | 0.90 | 1.13 | 9.21 | 1.03 | NA | 0.79 | 13.47 |
| | | **EPC** | **1.20** | **0.50** | **4.81** | **3.70** | **0.00** | **0.00** | **7.27** | **0.00** | **12.03** | **0.71** | **12.03** |
| Mallinckrodt Street | 163 | Maximum Detect | 2.29 | 3.21 | NA | 3.64 | 1.54 | 3.52 | 13.90 | 3.22 | NA | 2.38 | 50.30 |
| | | Distribution | X | X | NA | G | N | G | X | G | NA | L | G |
| | | 95% UCL | 1.10 | 1.48 | NA | 1.76 | 0.92 | 1.58 | 8.02 | 1.42 | NA | 1.31 | 17.96 |
| | | **EPC** | **0.96** | **0.58** | **0.00** | **0.00** | **0.00** | **0.42** | **6.08** | **0.33** | **16.52** | **1.23** | **16.52** |
| North Second Street | 497 | Maximum Detect | 12.70 | 13.70 | NA | 3.21 | 1.34 | 1.76 | 27.10 | 1.49 | NA | 1.80 | 19.40 |
| | | Distribution | X | X | NA | N | N | N | X | N | NA | X | X |
| | | 95% UCL | 5.99 | 6.65 | NA | 2.36 | 0.89 | 1.18 | 13.88 | 1.10 | NA | 0.99 | 12.91 |
| | | **EPC** | **5.85** | **5.75** | **0.00** | **0.00** | **0.00** | **0.02** | **11.94** | **0.01** | **11.47** | **0.91** | **11.47** |

[a] EPC was determined based upon table 2.15 of the Baseline Risk Assessment (DOE 1993)

[b] Background values were taken from Table 3-2 of the Background Soils Characterization Report for the St.Louis Downtown Site, St.Louis, Missouri (March 1999)

[c] Dataset contains four or less samples for which Pro-UCL cannot perform a statistical analysis. The background was subtracted from the maximum concentration to obtain the EPC.

G - Data distribution is gamma.

L - Data distribution is lognormal.

N - Data distribution is normal.

X - Data distribution is neither normal, lognormal nor gamma.

NA - No Data Available or Not Applicable

## Table K-4B. Property-Wide Exposure Point Concentrations for Metal Contaminants of Potential Concern in Inaccessible Soil Elevated Measurement Areas by Property: Utility Worker

| Property | Location | Inaccessible Soil COPC | Maximum Detection (mgkg) | Location of Maximum Detection | 95% UCL (mg/kg) | Data Distribution Type | EPC (mg/kg) | Soil Background [a] (mg/kg) | Is EPC > Background? (Yes/No) |
|---|---|---|---|---|---|---|---|---|---|
| Terminal RR (DT-9) | Main Tracks between Plants 6 and 6W | Cadmium | 69.3 | SLD124687 | 51.36 | Gamma | 51.36 | 1.03 | Yes |
| Thomas and Proetz Lumber (DT-10) | Office Building | Arsenic | 178 | SLD120307 | 139.9 | Normal | 139.9 | 10.6 | Yes |
| DT-12 (BNSF Railroad) | Adjacent to Plants 6 and 7 | Arsenic | 543 | SLD131212 | 166.80 | Gamma | 166.8 | 10.6 | Yes |

[a] Soil background value is the lesser of the 95% UCL and maximum detected concentration.

**Table K-5. Exposure Point Concentrations for Radiological Contaminants of Potential Concern Identified in Inaccessible Soil at the St. Louis City Property (DT-2): Recreational User**

| Property | Area ($m^2$) | Statistic (pCi/g) | Radiological COPC (pCi/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ac-227 | Pa-231 | Pb-210 [a] | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | U-234 [a] | U-235 | U-238 |
| Background [b] | | Mean | 0.14 | 0.90 | NA | 2.78 | 0.95 | 1.16 | 1.94 | 1.09 | NA | 0.08 | 1.44 |
| *Inaccessible Soil* | | | | | | | | | | | | | |
| DT-2 (City Property) | 12,665 | Maximum Detect | 1.87 | 1.85 | NA | 66.40 | 1.79 | 2.64 | 11.00 | 2.51 | NA | 1.56 | 12.50 |
| | | Distribution | X | X | NA | X | X | X | X | N | NA | X | X |
| | | 95% UCL | 0.09 | 0.14 | NA | 4.36 | 0.96 | 1.23 | 2.84 | 1.07 | NA | 0.22 | 2.89 |
| | | **EPC** | **0.00** | **0.00** | **2.05** | **1.58** | **0.01** | **0.07** | **0.90** | **0.00** | **1.45** | **0.14** | **1.45** |

[a] EPC was determined based upon table 2.15 of the Baseline Risk Assessment (DOE 1993)

[b] Background values were taken from Table 3-2 of the Background Soils Characterization Report for the St. Louis Downtown Site, St. Louis, Missouri (March 1999)

X - Data distribution is neither normal, lognormal nor gamma.

NA - No Data Available or Not Applicable

## Table K-6A. St. Louis Downtown Site-specific Soil Activity Fractions

| Radionuclide | Soil Concentration [a] (pCi/g) | Activity Fraction |
|---|---|---|
| Ac-227 | 15 | 0.022 |
| Pa-231 | 14 | 0.021 |
| Pb-210 | 50 | 0.074 |
| Ra-226 | 38 | 0.056 |
| Ra-228 | 4.7 | 0.007 |
| Th-228 | 5.8 | 0.009 |
| Th-230 | 90 | 0.134 |
| Th-232 | 5.8 | 0.009 |
| U-234 | 220 | 0.327 |
| U-235 | 10 | 0.015 |
| U-238 | 220 | 0.327 |
| **TOTAL** | **673.3** | **1** |

[a] Soil concentrations used to determine activity fractions are from Table 3.9 of the DOE's (1993) BRA.

**Table K-6B. Radiological Exposure Point Concentrations for Exterior Building Surfaces: Industrial Worker**

| | EPCs for RESRAD-Build Input ($pCi/m^2$) [a] | | |
|---|---|---|---|
| | Plant 1 | DT-10 Wood Storage | DT-14 Horizontal Beam Between Buildings |
| Radionuclide | Building 25 | Building | Warehouse [b] |
| Ac-227 | 1,272 | 3,540 | 560 |
| Pa-231 | 1,188 | 3,304 | 523 |
| Pb-210 | 4,242 | 11,799 | 1,868 |
| Ra-226 | 3,224 | 8,967 | 1,420 |
| Ra-228 | 399 | 1,109 | 176 |
| Th-228 | 492 | 1,369 | 217 |
| Th-230 | 7,635 | 21,238 | 3,362 |
| Th-232 | 492 | 1,369 | 217 |
| U-234 | 18,663 | 51,914 | 8,219 |
| U-235 | 848 | 2,360 | 374 |
| U-238 | 18,663 | 51,914 | 8,219 |

[a] Individual radionuclide exposure point concentration input values are calculated by multiplying the gross alpha UCL-95 value by the radionuclide specific activity fraction.

[b] EPC conservatively include gross alpha measurements for clay brick caps containing naturally occurring radioactivity.

## Table K-7. Exposure Point Concentrations for Metal Contaminants of Potential Concern Identified in Sewer Sediment by Sampling Location: Sewer Maintenance Worker

| Property | Sewer Sediment Location [a] | Location Description | Sewer Sediment COPC | EPC [b] (mg/kg) | Sediment Background [c] (mg/kg) | Is EPC > Background? (Yes/No) |
|---|---|---|---|---|---|---|
| Plant 1 | SLD123489 | Manhole along Salisbury Street | Arsenic | 5.9 | 11.8 | No |
| | | | Cadmium | 17.6 | 6.2 | Yes |
| Plant 1 | SLD123490 | Surface drain north of Bldg. 3 | Arsenic | 12.7 | 11.8 | Yes |
| Plant 1 | SLD123492 | Surface drain MH-56 | Arsenic | 5.1 | 11.8 | No |
| Plant 1 | SLD123493 | Surface drain MH-55 | Arsenic | 6.8 | 11.8 | No |
| Plant 1 | SLD123494 | Manhole MH-58 | Arsenic | 4.2 | 11.8 | No |
| Plant 1 | SLD123495 | Surface drain approx. 30 feet from the southwest corner of Bldg. G | Arsenic | 2.7 | 11.8 | No |
| Plant 1 | SLD123496 | Surface drain in the center of Bldgs. B, C, 10, F, and G | Arsenic | 17.1 | 11.8 | Yes |
| Plant 1 | SLD123498 | Surface Drain MH-66 | Arsenic | 2.8 | 11.8 | No |
| Plant 2 | SLD123740 | Surface drain MH-51 west of former 50-series bldgs. | Arsenic | 1.9 | 11.8 | No |
| Plant 2 | SLD123743 | Manhole MH-37 | Arsenic | 1.7 | 11.8 | No |
| Plant 2 | SLD123744 | Manhole MH-39 south of plant along Destrehan Street | Arsenic | 2.1 | 11.8 | No |
| Plant 2 | SLD123749 | Surface drain north of Bldg. 502 | Arsenic | 1.3 | 11.8 | No |
| Plant 2 | SLD123750 | Curb drain outside of plant along North Second Street | Arsenic | 2.8 | 11.8 | No |
| Plant 6 | SLD123748 | Surface drain MH-30 along western plant boundary | Arsenic | 2.6 | 11.8 | No |
| DT-11 | SLD123488 | Manhole MH-1 just south of McKinley Bridge | Arsenic | 3.9 | 11.8 | No |

[a] Sediment location selected based on exceedances of industrial screening levels.

[b] The EPC is the concentration measured in the sediment sample collected from the specified sewer location.

[c] Because all 95/95 UTL values are greater than the maximum detection, the recommended BV is the lesser of the 95% UCL and the maximum detection.

## Table K-8A. Exposure Point Concentrations for Radiological Contaminants of Potential Concern Identified in Inaccessible Soil Adjacent to Sewer Lines by Property/Borehole Location: Sewer Utility Worker

| Property | Area ($m^2$) | Statistic (pCi/g) | Radiological COPC (pCi/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Ac-227** | **Pa-231** | **Pb-210[a]** | **Ra-226** | **Ra-228** | **Th-228** | **Th-230** | **Th-232** | **U-234[a]** | **U-235** | **U-238** |
| Background[b] | | Mean | 0.14 | 0.90 | NA | 2.78 | 0.95 | 1.16 | 1.94 | 1.09 | NA | 0.08 | 1.44 |
| ***Mallinckrodt Properties*** | | | | | | | | | | | | | |
| Plant 1[c] (SLD124540) | 180 | Maximum Detect | 2.11 | 1.50 | NA | 4.66 | 1.08 | 2.12 | 24.00 | 1.59 | NA | 3.69 | 78.60 |
| | | **EPC** | **1.97** | **0.60** | **2.44** | **1.88** | **0.13** | **0.96** | **22.06** | **0.50** | **77.16** | **3.61** | **77.16** |
| Plant 6[c] (HTZ88929, HTZ88930) | 180 | Maximum Detect | 44.80 | 56.30 | NA | 58.30 | 1.16 | 1.64 | 489.00 | 1.60 | NA | 0.93 | 3.69 |
| | | **EPC** | **44.66** | **55.40** | **72.18** | **55.52** | **0.21** | **0.48** | **487.06** | **0.51** | **2.25** | **0.85** | **2.25** |
| ***Industrial/Commercial Vicinity Properties*** | | | | | | | | | | | | | |
| City Property (DT-2), Sewer Line Beneath Levee[c, d] | 180 | Maximum Detect | 11.60 | 14.10 | NA | 45.20 | 1.55 | 1.55 | 1180.00 | 1.55 | NA | 1.31 | 35.30 |
| | | **EPC** | **11.46** | **13.20** | **55.15** | **42.42** | **0.60** | **0.39** | **1178.06** | **0.46** | **33.86** | **1.23** | **33.86** |
| ***Railroad Properties*** | | | | | | | | | | | | | |
| Plant 7N/BNSF RR (DT-12) Sewer Line beneath RR Tracks[c, e] | 180 | Maximum Detect | 153.00 | 170.00 | NA | 117.00 | 2.56 | 2.56 | 10180.00 | 2.56 | NA | 1.68 | 48.70 |
| | | **EPC** | **152.86** | **169.10** | **148.49** | **114.22** | **1.61** | **1.40** | **10178.06** | **1.47** | **47.26** | **1.60** | **47.26** |

[a] EPC was determined based upon table 2.15 of the Baseline Risk Assessment (DOE 1993)

[b] Background values were taken from Table 3-2 of the Background Soils Characterization Report for the St. Louis Downtown Site, St. Louis, Missouri (March 1999)

[c] Dataset contains four or less samples for which Pro-UCL cannot perform a statistical analysis. The background was subtracted from the maximum concentration to obtain the EPC.

[d] Samples SLD120945, SLD120946, SLD120947, SLD120948

[e] Samples SLD93275, SLD93276, SLD93277

NA - No Data Available or Not Applicable

## Table K-8B. Exposure Point Concentrations for Metal Contaminants of Potential Concern Identified in Inaccessible Soil Adjacent to Sewer Lines by Property/Borehole Location: Sewer Utility Worker

| Property [a] | Soil Borehole Location | Description Relative to Sediment Locations | Inaccessible Soil COPC | EPC [b] (mg/kg) | Soil Background [c] (mg/kg) | Is EPC > Background? (Yes/No) |
|---|---|---|---|---|---|---|
| Plant 1 | SLD124540 | Approximately 30 ft east and downstream of surface drain location SLD123495. | Arsenic | 130 | 10.6 | Yes |
| | | | Cadmium | 33.8 | 1.03 | Yes |
| Plant 1 | SLD124546 | Located outside of northwest plant boundary along Salisbury St.; downstream of surface drain location SLD123492 (MH-56). | Arsenic | 60.9 | 10.6 | Yes |
| Plant 1 | SLD124548 | Located adjacent to surface drain SLD123491 (MH-59), northwest of Bldg. 10. | Cadmium | 1,730 | 1.03 | Yes |
| Plant 1 | SLD124554 | Located approx. 60 ft to the east and downstream of surface drain SLD123491 (MH-59); just northeast of Bldg. 10. | Cadmium | 28.8 | 1.03 | Yes |
| Plant 1 | SLD125521 | Located approx. 30 ft to the north and downstream of surface drain MH-46 (not sampled), and upstream (south) of surface drain SLD123491 (MH-59). | Cadmium | 28.9 | 1.03 | Yes |

[a] Soil borehole location selected based on exceedances of industrial screening levels.

[b] The EPC is represented by the maximum concentration detected at the borehole location.

[c] Soil backgound value is represented by the lesser of the 95% UCL and the maximum detected concentration.

## Table K-9. Input Values for Non-Default Residual Radioactivity Model Parameters

| Parameter | Unit | RESRAD Default | Industrial Worker | Construction/ Utility Worker | Recreational User |
|---|---|---|---|---|---|
| ***Soil Concentrations/Transport Factors*** | | | | | |
| Soil Concentrations | pCi/g | NA | Table K-2A | Tables K-3A, K-4A, & K-8A | Table K-5 |
| ***Contaminated Zone Parameters*** | | | | | |
| Area of Contaminated Zone | $m^2$ | 10,000 | Property-specific | 180/Property-Specific [a] | 12,665 |
| Thickness of Contaminated Zone (All Properties) | m | 2 | 2 | 2 [b] | 2 |
| ***Cover/Hydrological Data*** | | | | | |
| Cover Depth | m | 0 | 0 | 0 | 1.0 |
| Density of Cover Material | $g/cm^3$ | 1.5 | Not used | Not used | 1.5 |
| Cover Erosion Rate | m/year | 0.001 | Not used | Not used | 0.00006 |
| Density of Contaminated Zone | $g/cm^3$ | 1.5 | 1.28 | 1.28 | 1.5 |
| Contaminated Zone Erosion Rate | m/year | 0.001 | 0.00006 | 0.00006 | 0.00006 |
| Contaminated Zone Total Porosity | unitless | 0.40 | 0.42 | 0.42 | 0.40 |
| Contaminated Zone Field Capacity | unitless | 0.20 | 0.36 | 0.36 | 0.20 |
| Contaminated Zone Hydraulic Conductivity | m/yr | 10.00 | 3.048 | 3.048 | 10.00 |
| Contaminated Zone B Parameter | unitless | 5.30 | 10.40 | 10.40 | 5.30 |
| Wind Speed | m/sec | 2.00 | 4.17 | 4.17 | 2.00 |
| Precipitation | m/yr | 1.00 | 0.92 | 0.92 | 1.00 |
| Irrigation | m/yr | 0.20 | 0.00 | 0.00 | 0.20 |
| Runoff Coefficient | unitless | 0.20 | 0.80 | 0.80 | 0.20 |
| ***Occupancy Data*** | | | | | |
| Inhalation Rate | $m^3$/year | 8,400 | 10,550 | 10,550 | 9,326 |
| Mass Loading for Inhalation | $g/m^2$ | 0.0001 | 0.0002 | 0.0002 | 0.0001 |
| Indoor Dust Filtration Factor | unitless | 0.4 | 0.5 | 0.5 | 0.4 |
| Exposure Duration | year | 30 | 25 | 1 | 9 |
| Indoor Time Fraction | unitless | 0.5 | 0.1969 | 0 | 0 |
| Outdoor Time Fraction | unitless | 0.25 | 0.04566 | 0.082/0.0091 [c] | 0.0086 |
| ***Ingestion Dietary Data*** | | | | | |
| Soil Ingestion Rate | g/year | 36.5 | 49.64 | 175.2 | 18.25 |
| ***Pathways*** | | | | | |
| External Gamma | unitless | Active | Active | Active | Active |
| Inhalation | unitless | Active | Active | Active | Active |
| Plant Ingestion | unitless | Active | Suppressed | Suppressed | Suppressed |
| Meat Ingestion | unitless | Active | Suppressed | Suppressed | Suppressed |
| Milk Ingestion | unitless | Active | Suppressed | Suppressed | Suppressed |
| Aquatic Foods | unitless | Active | Suppressed | Suppressed | Suppressed |
| Drinking Water | unitless | Active | Suppressed | Suppressed | Suppressed |
| Soil Ingestion | unitless | Active | Active | Active | Active |
| Radon | unitless | Suppressed | Suppressed | Suppressed | Suppressed |

[a] Area of contaminated zone is assumed to be 180 m2 for a utility worker working adjacent to sewer lines, and is property-specific for all other areas.

[b] The thickness of contamination parameter was entered as 1 m for the DT-2 soil adjacent to sewer lines construction worker, as sewer excavation data were available.

[c] Outdoor time fraction is 0.082 for a construction worker (720 hours/year) and 0.0091 for a utility worker (80 hours/year).

NA = Parameter is not applicable to receptor scenario.

# Table K-10. Input Values for Non-default Residual Radioactivity-Build Model Parameters

| Parameter | Unit | RESRAD-Build Default | Industrial Worker |
|---|---|---|---|
| ***Case*** | | | |
| Dose/Risk Library | NA | FGR 11 | FGR 11 |
| ***Time Parameters*** | | | |
| Exposure Duration | days | 365 | 365 |
| Indoor Fraction | unitless | 0.5 | 0.0034 |
| ***Building Parameters*** | | | |
| Number of Rooms | NA | 1 | 1 |
| Area | $m^2$ | 36 | 100 |
| ***Receptor Parameters*** | | | |
| Number of Receptors | unitless | 1 | 1 |
| Time Fraction | unitless | 1 | 1 |
| Breathing Rate | $m^3$/day | 18 | 33.6 |
| Location (x,y,z) | m | 1,1,1 | 5, 5, 1 |
| ***Shielding Parameters*** | | | |
| ***Source Parameters*** | | | |
| Number of Sources | unitless | 1 | 5 |
| Type | unitless | Volume | Area |
| Direction | unitless | X | Floor (z), four walls (x,y,x,y) |
| Location (x,y,z) | m | 0,0,0 | Floor: 5, 5, 0; Walls: 10, 5, 1 5, 10, 1 0, 5, 1; 5, 0, 1 |
| Geometry (circular or rectangle) | NA | Circular | Circular |
| Area (volume, area, point source) | $m^2$ | 36 | 100, 20, 20, 20, 20 |
| ***Release*** | | | |
| Air Fraction (all sources) | NA | 0.1 | 0.07 |
| Direct Ingestion (all sources) | 1/h | 0 | 0 |
| Removable Fraction (area, line, point source) | unitless | 0.5 | 0.2 |
| Lifetime (area, line, point source) | days | 365 | 10,000 |
| ***Pathways*** | | | |
| External | NA | Active | Active |
| Inhalation | NA | Active | Active |
| Ingestion | NA | Active | Active |

FGR = Federal Guidance Report.

**Table K-11. Input Values for Pathway Dose Equations: Exposures to Metal Contaminants of Potential Concern**

| Exposure Pathway | Exposure Parameter | Exposure Parameter Description | Units | Exposure Parameter Value | Source/Comments |
|---|---|---|---|---|---|
| General Assumptions - All Pathways | $BW_a$ | Adult Body Weight | kg | 71.8 | USEPA (1997a) |
| | $ED_{cw}$ | Exposure Duration for Construction Worker | years | 1 | USEPA (1997a) |
| | $ED_{iw}$ | Exposure Duration for Industrial Worker | years | 25 | USEPA (1997a) |
| | $ED_{mw}$ | Exposure Duration for Sewer Maintenance Worker | years | 25 | USEPA (1997a) |
| | $ED_{uw}$ | Exposure Duration for Utility Worker | years | 1 | USEPA (1989a) |
| | $EF_{cw-sl}$ | Soil Exposure Frequency for Construction Worker | days/year | 90 | Exposure frequency applied to road workers at North St. Louis County FUSRAP sites. |
| | $EF_{iw-sl}$ | Soil Exposure Frequency for Industrial Worker | days/year | 50 | USACE (1998b). Exposure frequency corresponds to 400 hours assumed for time spent outdoors. |
| | $EF_{mw-sd}$ | Sediment Exposure Frequency for Sewer Maintenance Worker | days/year | 1 | Conservative estimate of exposure frequency for a City sewer worker at one manhole location. |
| | $EF_{uw-sl}$ | Exposure Frequency for Utility Worker | days/year | 10 | USACE (1998b) exposure frequency assumed to be a one-time 80-hour exposure. |
| Soil/Sediment Ingestion | $FI_{cw-sl}$ | Fraction Contaminated Soil Ingested by Construction Worker | unitless | 1 | USEPA (1989a) |
| | $FI_{iw-sl}$ | Fraction Contaminated Soil Ingested by Industrial Worker | unitless | 1 | USEPA (1989a) |
| | $FI_{mw-sd}$ | Fraction Contaminated Sediment Ingested by Sewer Maintenance Worker | unitless | 1 | USEPA (1989a) |
| | $FI_{uw-sl}$ | Fraction Contaminated Soil Ingested by Utility Worker | unitless | 1 | USEPA (1989a) |
| | $IR_{cw-sl}$ | Soil Ingestion Rate for Construction Worker | mg/day | 480 | USEPA (1996a, 2002b) |
| | $IR_{iw-sl}$ | Soil Ingestion Rate for Industrial Worker | mg/day | 136 | USACE (1998b) |
| | $IR_{mw-sd}$ | Sediment Ingestion Rate for Sewer Maintenance Worker | mg/day | 330 | USACE (1996a, 2002b) |
| | $IR_{uw-sl}$ | Soil Ingestion Rate for Utility Worker | mg/day | 480 | USEPA (1996a, 2002b) |
| | $AT_{c-ing}$ | Carcinogenic Averaging Time for All Receptors | days | 25,550 | Calculated value per USEPA (1989a): $AT_{c-ing} = 70\,years \times 365\frac{days}{year}$ |
| | $AT_{cw-nc-ing}$ | Noncarcinogenic Averaging Time for Construction Worker | days | 365 | Calculated value per USEPA (1989a): $AT_{cw-nc-ing} = ED_{uw} \times 365\frac{days}{year}$ |
| | $AT_{iw-nc-ing}$ | Noncarcinogenic Averaging Time for Industrial Worker | days | 9,125 | Calculated value per USEPA (1989a): $AT_{iw-nc-ing} = ED_{iw} \times 365\frac{days}{year}$ |
| | $AT_{mw-nc-ing}$ | Noncarcinogenic Averaging Time for Sewer Maintenance Worker | days | 9,125 | Calculated value per USEPA (1989a): $AT_{mw-nc-ing} = ED_{mw} \times 365\frac{days}{year}$ |
| | $AT_{uw-nc-ing}$ | Noncarcinogenic Averaging Time for Utility Worker | days | 365 | Calculated value per USEPA (1989a): $AT_{uw-nc-ing} = ED_{uw} \times 365\frac{days}{year}$ |

**Table K-11. Input Values for Pathway Dose Equations: Exposures to Metal Contaminants of Potential Concern (Continued)**

| Exposure Pathway | Exposure Parameter | Exposure Parameter Description | Units | Exposure Parameter Value | Source/Comments |
|---|---|---|---|---|---|
| Soil/Sediment - Dermal Absorption | $ABS$ | Dermal Absorption Factors (ABS) for All Receptors Being Evaluated: | | | |
| | | Arsenic | unitless | 0.03 | USEPA (2004) |
| | | Cadmium | unitless | 0.001 | USEPA (2004) |
| | $AF_{cw-sl}$ | Soil-Skin Adherence Factor for Construction Worker | $mg/cm^2$-event | 0.3 | USEPA (2004) |
| | $AF_{iw-sl}$ | Soil-Skin Adherence Factor for Industrial Worker | $mg/cm^2$-event | 0.3 | USEPA (2004) |
| | $AF_{mw-sd}$ | Sediment-Skin Adherence Factor for Sewer Maintenance Worker | $mg/cm^2$-event | 13 | USEPA (2004) |
| | $AF_{uw-sl}$ | Soil-Skin Adherence Factor for Utility Worker | $mg/cm^2$-event | 0.3 | USEPA (2004) |
| | $EV_{cw-sl}$ | Soil Contact Event Frequency – Construction Worker | events/day | 1 | USEPA (2004) |
| | $EV_{iw-sl}$ | Soil Contact Event Frequency – Industrial Worker | events/day | 1 | USEPA (2004) |
| | $EV_{mw-sd}$ | Sediment Contact Event Frequency – Sewer Maintenance Worker | events/day | 1 | USEPA (2004) |
| | $EV_{uw-sl}$ | Soil Contact Event Frequency Contact for Utility Worker | events/day | 1 | USEPA (2004) |
| | $SA_{cw-sl}$ | Skin Surface Area Available for Soil Contact for Construction Worker | $cm^2$/day | 2,479 | Calculated value for outdoor worker per USEPA (2004), Appendix C-1 - sum of 50th percentile values for face, forearms, and hands. |
| | $SA_{iw-sl}$ | Skin Surface Area Available for Soil Contact for Industrial Worker | $cm^2$/day | 2,479 | Calculated value for outdoor worker per USEPA (2004), Appendix C-1 - sum of 50th percentile values for face, forearms, and hands. |
| | $SA_{mw-sd}$ | Skin Surface Area Available for Sediment Contact for Sewer Maintenance Worker | $cm^2$/day | 2,479 | Calculated value for outdoor worker per USEPA (2004), Appendix C-1 - sum of 50th percentile values for face, forearms, and hands. |
| | $SA_{uw-sl}$ | Skin Surface Area Available for Sediment Contact for Utility Worker | $cm^2$/day | 2,479 | Calculated value per USEPA (2004), Appendix C-1 - sum of 50th percentile values for face, forearms, and hands. |
| | $AT_{c-derm}$ | Carcinogenic Averaging Time for All Receptors | days | 25,550 | Calculated value per USEPA (1989a): $AT_{c-derm} = 70\, years \times 365 \frac{days}{year}$ |
| | $AT_{cw-nc-derm}$ | Noncarcinogenic Averaging Time for Construction Worker | days | 365 | Calculated value per USEPA (1989a): $AT_{cw-nc-ing} = ED_{uw} \times 365 \frac{days}{year}$ |
| | $AT_{iw-nc-derm}$ | Noncarcinogenic Averaging Time for Industrial Worker | days | 9,125 | Calculated value per USEPA (1989a): $AT_{iw-nc-derm} = ED_{iw} \times 365 \frac{days}{year}$ |
| | $AT_{mw-nc-derm}$ | Noncarcinogenic Averaging Time for Sewer Maintenance Worker | days | 9,125 | Calculated value per USEPA (1989a): $AT_{mw-nc-derm} = ED_{mw} \times 365 \frac{days}{year}$ |
| | $AT_{uw-nc-derm}$ | Noncarcinogenic Averaging Time for Utility Worker | days | 365 | Calculated value per USEPA (1989a): $AT_{uw-nc-derm} = ED_{uw} \times 365 \frac{days}{year}$ |
| Soil - Inhalation | $ET_{cw-sl-inh}$ | Soil Exposure Time for Construction Worker | hr/day | 8 | RAIS (DOE 2011), assumption based on length of work day |
| | $ET_{iw-sl-inh}$ | Soil Exposure Time for Industrial Worker | hr/day | 8 | RAIS (DOE 2011), assumption based on length of work day |
| | $ET_{uw-sl-inh}$ | Soil Exposure Time for Utility Worker | hr/day | 8 | RAIS (DOE 2011), assumption based on length of work day |
| | $PEF_{cw}$ | Particulate Emission Factor for Construction Worker | $m^3$/kg | $6.58 \times 10^8$ | Calculated value per USEPA (2002b). Value assumes 0% vegetative cover of the site |
| | $PEF_{iw}$ | Particulate Emission Factor for Industrial Worker | $m^3$/kg | $1.36 \times 10^9$ | USEPA (2002b). Default value for industrial worker. |
| | $PEF_{uw}$ | Particulate Emission Factor for Utility Worker | $m^3$/kg | $6.58 \times 10^8$ | Calculated value per USEPA (2002b). Value assumes 0% vegetative cover of the site |
| | $AT_{c-inh}$ | Carcinogenic Averaging Time for All Receptors | hr | 613,200 | Calculated value per USEPA (2009b): $AT_{c-inh} = 70\, years \times 365 \frac{days}{year} \times 24 \frac{hr}{day}$ |
| | $AT_{cw-nc-inh}$ | Noncarcinogenic Averaging Time for Construction Worker | hr | 219,000 | Calculated value per USEPA (2009b): $AT_{iw-nc-inh} = ED_{iw} \times 365 \frac{days}{year} \times 24 \frac{hr}{day}$ |
| | $AT_{iw-nc-inh}$ | Noncarcinogenic Averaging Time for Industrial Worker | hr | 219,000 | Calculated value per USEPA (2009b): $AT_{iw-nc-inh} = ED_{iw} \times 365 \frac{days}{year} \times 24 \frac{hr}{day}$ |
| | $AT_{uw-nc-inh}$ | Noncarcinogenic Averaging Time for Utility Worker | hr | 8,760 | Calculated value per USEPA (2009b): $AT_{uw-nc-inh} = ED_{uw} \times 365 \frac{days}{year} \times 24 \frac{hr}{day}$ |

## Table K-12. Cancer Slope Factors for Radiological COPCs

| CAS Number | Isotope | Radioactive Half-Life | ICRP Lung Type | GI Absorption Fraction | Water Ingestion | Food Ingestion | Soil Ingestion | Inhalation | External Exposure | Source |
|---|---|---|---|---|---|---|---|---|---|---|
| | | years | | Risk/pCi | | | | | Risk/yr per pCi/g | |
| 14952-40-0 | Ac-227+D | 2.18E+01 | S | 5.00E-04 | 4.86E-10 | 6.53E-10 | 1.16E-09 | 2.09E-07 | 1.47E-06 | FGR-13 Morbidity [a] |
| 14331-85-2 | Pa-231 | 3.28E+04 | S | 5.00E-04 | 1.73E-10 | 2.26E-10 | 3.74E-10 | 4.55E-08 | 1.39E-07 | FGR-13 Morbidity [a] |
| 14255-04-0 | Pb-210+D | 2.23E+01 | M | 2.00E-01 | 1.27E-09 | 3.44E-09 | 2.66E-09 | 1.39E-08 | 4.21E-09 | FGR-13 Morbidity [a] |
| 13982-63-3 | Ra-226+D | 1.60E+03 | M | 2.00E-01 | 3.86E-10 | 5.15E-10 | 7.30E-10 | 1.16E-08 | 8.49E-06 | FGR-13 Morbidity [a] |
| 15262-20-1 | Ra-228+D | 5.75E+00 | M | 2.00E-01 | 1.04E-09 | 1.43E-09 | 2.29E-09 | 5.23E-09 | 4.53E-06 | FGR-13 Morbidity [a] |
| 14274-82-9 | Th-228+D | 1.91E+00 | S | 5.00E-04 | 3.00E-10 | 4.22E-10 | 8.09E-10 | 1.43E-07 | 7.76E-06 | FGR-13 Morbidity [a] |
| 14269-63-7 | Th-230 | 7.70E+04 | S | 5.00E-04 | 9.10E-11 | 1.19E-10 | 2.02E-10 | 2.85E-08 | 8.19E-10 | FGR-13 Morbidity [a] |
| 7440-29-1 | Th-232 | 1.41E+10 | S | 5.00E-04 | 1.01E-10 | 1.33E-10 | 2.31E-10 | 4.33E-08 | 3.42E-10 | FGR-13 Morbidity [a] |
| 13966-29-5 | U-234 | 2.45E+05 | M | 2.00E-02 | 7.07E-11 | 9.55E-11 | 1.58E-10 | 1.14E-08 | 2.52E-10 | FGR-13 Morbidity [a] |
| 15117-96-1 | U-235+D | 7.04E+08 | M | 2.00E-02 | 7.18E-11 | 9.76E-11 | 1.63E-10 | 1.01E-08 | 5.43E-07 | FGR-13 Morbidity [a] |
| 7440-61-1 | U-238 | 4.47E+09 | M | 2.00E-02 | 6.40E-11 | 8.66E-11 | 1.43E-10 | 9.32E-09 | 4.99E-11 | FGR-13 Morbidity [a] |
| 7440-61-1 | U-238+D | 4.47E+09 | M | 2.00E-02 | 8.71E-11 | 1.21E-10 | 2.10E-10 | 9.35E-09 | 1.14E-07 | FGR-13 Morbidity [a] |

[a] USEPA 1999b.

## Table K-13A. Toxicity Criteria for Metal Contaminants of Potential Concern: Carcinogenic Effects

| COPC: | Arsenic | Cadmium [a] | Lead [b] |
|---|---|---|---|
| CAS Number: | 7440-38-2 | 7440-43-9 | 7439-92-1 |
| Weight of Evidence Classification [c] | A | B1 | B2 |
| ***Oral Exposure Route*** | | | |
| $SF_o$, $(mg/kg/day)^{-1}$ | 1.5E+00 | NA | NA |
| Type of Cancer | Organ (liver, kidney, lung, and bladder); Skin | NA | Kidneys (renal tumors); genetic expression |
| $SF_o$ Basis | Drinking Water | NA | Dietary/subcutaneous exposures to rats/mice |
| $SF_o$ Source | USEPA (2011b) | USEPA (2011b) | USEPA (2011b) |
| ***Dermal Exposure Route*** | | | |
| $SF_d$, $(mg/kg/day)^{-1}$ [d] | 1.6E+00 | NA | NA |
| ABS, unitless [e] | 0.03 | 0.001 | NA |
| GIABS, % [e] | 95 | 0.025 | 100 |
| $SF_d$ Source | Calculated from $SF_o$ | NA | NA |
| ***Inhalation Exposure Route*** | | | |
| IUR, $(\mu g/m^3)^{-1}$ | 4.3E-03 | 1.8E-03 | NA |
| Type of Cancer | Lung | Lung, trachea, bronchial | NA |
| IUR Basis | Inhalation | Inhalation & injection studies on rats and mice | NA |
| IUR Source | USEPA (2011b) | USEPA (2011b) | USEPA (2011b) |

[a] The $SF_o$, ABS, and GIABS values for cadmium are based on diet.

[b] No toxicity criteria are established for determining risk due to lead exposures.

[c] Weight of Evidence (WOE) Classifications:

A - Human carcinogen

B1 - Probable human carcinogen - based on limited evidence of carcinogenicity in humans

B2 - Probable human carcinogen - based on sufficient evidence of carcinogenicity in animals

[d] Calculated using the following equation: $SF_d = SF_o \div GIABS\ (\%)$.

[e] ABS (dermal absorption fraction from soil) and GIABS (gastrointestinal absorption efficiencies) obtained from RAGS Part E (USEPA 2004) and USEPA's (2011a) most recent Regional Screening Levels Table. Default GIABS value of 100% is assumed for COPCs that lack available published data (USEPA, 2004).

IUR - Inhalation unit risk.

$SF_d$ - Dermal cancer slope factor.

$SF_o$ - Oral cancer slope factor.

NA - No published oral slope factor is available.

**Table K-13B. Toxicity Criteria for Metal Contaminants of Potential Concern: Noncarcinogenic Effects**

| COPC: | Arsenic | Cadmium [a] | Lead [b] |
|---|---|---|---|
| CAS Number: | 7440-38-2 | 7440-43-9 | 7439-92-1 |
| ***Oral Exposure Route*** | | | |
| $RfD_o$, mg/kg/day | 3.0E-04 | 1.0E-03 | [c] |
| RfDo Basis | Human chronic oral studies | Human studies | [c] |
| Critical Effect(s) | Skin/hyperpigmentation, keratosis: Cardiovascular/possible vascular complications, congestive heart failure | Kidney/Significant proteinuria | Anemia, hypertension, developmental effects |
| Confidence Level | Medium | High | [c] |
| Uncertainty Factor, unitless | 3 | 10 | [c] |
| $RfD_o$ Source | USEPA (2011b) | USEPA (2011b) | ATSDR (2007) |
| ***Dermal Exposure Route*** | | | |
| $RfD_d$, mg/kg/day [d] | 2.9E-04 | [c] | [c] |
| ABS, unitless [e] | 0.03 | 0.001 | [c] |
| GIABS, % [e] | 95 | 0.025 | 100 |
| $RfD_d$ Source | Calculated from $RfD_o$ | [c] | [c] |
| ***Inhalation Exposure Route*** | | | |
| RfC, $mg/m^3$ | 1.5E-05 | 1.0E-05 | [c] |
| RfC Basis | [c] | [c] | [c] |
| Critical Effect(s) | Development effects, cardiovascular system, nervous system | Respiratory/pulmonary effects | Anemia, hypertension, developmental effects |
| Confidence Level | [c] | [c] | [c] |
| Uncertainty Factor, unitless | [c] | [c] | [c] |
| RfC Source | CalEPA (2011) | USEPA (2011a) | ATSDR (2007) |

## Table K-13B. Toxicity Criteria for Metal Contaminants of Potential Concern: Noncarcinogenic Effects

| COPC: | Arsenic | Cadmium [a] | Lead [b] |
|---|---|---|---|
| ***Target Organs*** | | | |
| Blood Chemistry/Erythrocytes | | | X |
| Cardiovascular System | X | | X |
| Central Nervous System/Neurotoxicity | X | | |
| Fetus (Development) | X | | X |
| Kidneys | | X [f] | |
| Pulmonary/Respiratory System | | X [f] | |
| Skin | X | | |

[a] The $RfD_o$, ABS, and GIABS values for cadmium are based on diet.

[b] No toxicity criteria are established for determining risk due to lead exposures.

[c] Information is currently not available.

[d] Calculated using the following equation: Dermal RfD = Oral RfD x GIABS (%).

[e] ABS (dermal absorption fraction from soil) and GIABS (gastrointestinal absorption efficiencies) obtained from RAGS Part E (USEPA 2004) and USEPA's (2011a) most recent Regional Screening Levels Table. Default GIABS value of 100% is assumed for COPCs that lack available published data (USEPA, 2004).

[f] Target organs are applicable to cadmium exposures via diet and water ingestion.

RfC - Inhalation reference concentration.

$SF_d$ - Dermal cancer slope factor.

$SF_o$ - Oral cancer slope factor.

X - Indicates target organ/organ system for COPC.

## Table K-13C. Summary of Target Organs and Critical Effects for Non-carcinogenic Exposures to Metal Contaminants of Potential Concern

| CAS No. | COPC | Target Organ/Critical Effect [a] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Blood Chemistry/ Erythrocytes | Cardiovascular | Central Nervous System/ Neurotoxicity | Developmental (Including Fetal) Effects | Kidneys | Pulmonary/ Respiratory System | Skin |
| 7440-38-2 | Arsenic | | X | X | X | | | X |
| 7440-43-9 | Cadmium (Diet) | | | | | X | X | |
| 7440-43-9 | Cadmium (Water) | | | | | X | X | |
| 7439-92-1 | Lead | X | X | | X | | | |

[a] Sources for target organs/critical effects are the same as those cited in Table K-13B.

## Table K-14A. Property-Wide Radiological Dose and Risk Characterization for Inaccessible Soil by Property: Industrial Worker

| Property | Total Dose/Risk | |
|---|---|---|
| | Max. Dose (mrem/yr) | Max. CR (unitless) |
| ***Mallinckrodt Properties*** | | |
| Plant 1 | **31** | **5.4E-04** |
| Plant 2 | 2 | **2.9E-05** |
| Plant 6 | 22 | **3.7E-04** |
| ***Industrial/Commerical Vicinity Properties*** | | |
| DT-2 (City of St. Louis Property) | 3 | **6.1E-05** |
| DT-4 (Gunther Salt North) | **48** | **8.4E-04** |
| DT-6 (Heintz Steel) | 18 | **3.5E-04** |
| DT-8 (PSC Metals, Inc.) | 0.2 | 4.1E-06 |
| ***Railroad Vicinity Properties*** | | |
| DT-3 (Norfolk Southern Railroad) | 2 | **3.0E-05** |
| DT-9 (Terminal Railroad) Rail Yard | 18 | **3.3E-04** |
| DT-9 (Terminal Railroad) Main Line | 2 | **4.1E-05** |
| DT-9 (Terminal Railroad) Soil Spoils Area | 18 | **3.3E-04** |
| DT-12 (BNSF Railroad) | 2 | **2.9E-05** |
| ***Roadways*** | | |
| Angelrodt Street | 2 | **4.0E-05** |
| Destrehan Street | 7 | **1.3E-04** |
| Hall Street | 4 | **7.0E-05** |
| Mallinckrodt Street | 1 | **2.0E-05** |
| North Second Street | 2 | **3.1E-05** |

**Bold font** indicates that the CR is greater than the target of 1.0E-05. **Bold font** with gray shading indicates that the dose or COR is greater than the 25 mrem/yr benchmark or USEPA's highest target value of 1.0E-04, respectively.

## Table K-14B. Property-Wide Metals Risk Characterization for Inaccessible Soil by Property: Industrial Worker

| Property/Location | Carcinogenic Effects | | Non-carcinogenic Effects | | EPC versus Background | | |
|---|---|---|---|---|---|---|---|
| | Total Property CR | Risk Driver COPC | Total Property HI | Risk Driver COPC | EPC (mg/kg) | Background (mg/kg) [a] | Is EPC > Background? |
| Terminal RR Main Tracks (DT-9) [b] | 9.8E-10 | Cadmium | 2.5E-02 | Cadmium | 22.0 | 1 | Yes |
| Thomas & Proetz Lumber (DT-10) [c] | **2.7E-05** | **Arsenic** | 1.7E-01 | Arsenic | 162.5 | 10.6 | Yes |
| BNSF RR (DT-12) [d] | **2.7E-05** | **Arsenic** | 1.7E-01 | Arsenic | 166.8 | 10.6 | Yes |

[a] Soil background value is the lesser of the 95% UCL and maximum detected value.

[b] EPC is based on a 95% UCL for all inaccessible soil arsenic data collected from DT-9 Main Tracks (between Mallinckrodt and Destrehan Streets).

[c] EPC is based on a 95% UCL for all inaccessible soil arsenic data collected from DT-10.

[d] EPC is based on a 95% UCL for all inaccessible soil arsenic data collected from DT-12 (adjacent to Plants 6 and 7).

CR = Cancer risk

HI = Hazard index

NA = Not Applicable

**Bold** indicates carcinogenic risk or noncarcinogenic HQ/HI exceeding EPA's de-minimis levels of 1E-05 or 1.0, respectively.

**Table K-15A. Property-Wide Exposure Point Concentrations for Radiological Contaminants of Potential Concern for Combined Inaccessible and Accessible Soil at Plant Properties, Industrial/Commercial Vicinity Properties, Railroad Properties and Roadways: Industrial Worker and Recreational User**

| Property | Area ($m^2$) | Statistic (pCi/g) | Radiological COPC (pCi/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ac-227 | Pa-231 | Pb-210 [a] | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | U-234 [a] | U-235 | U-238 |
| Background [b] | | Mean | 0.14 | 0.90 | NA | 2.78 | 0.95 | 1.16 | 1.94 | 1.09 | NA | 0.08 | 1.44 |
| ***Industrial Worker - Mallinckrodt Properties*** | | | | | | | | | | | | | |
| Plant 1 ISOU | 10,500 | EPC | 1.18 | 0.37 | 17.91 | 13.78 | 0.00 | 0.10 | 16.29 | 0.00 | 22.53 | 1.20 | 22.53 |
| Plant 1 Accessible | 11,700 | EPC | 0.06 | 0.00 | 0.11 | 0.08 | 0.00 | 0.10 | 1.23 | 0.28 | 3.05 | 0.23 | 3.05 |
| Plant 1 Total | 22,200 | **Combined EPC [c]** | **0.59** | **0.18** | **8.53** | **6.56** | **0.00** | **0.10** | **8.36** | **0.14** | **12.26** | **0.69** | **12.26** |
| Plant 2 ISOU | 3,563 | EPC | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 | 0.41 | 1.28 | 0.19 | 22.01 | 2.00 | 22.01 |
| Plant 2 Accessible | 16,531 | EPC | 0.00 | 0.13 | 0.10 | 0.10 | 0.00 | 0.14 | 0.00 | 0.00 | 2.01 | 0.00 | 2.01 |
| Plant 2 Total | 20,094 | **Combined EPC [c]** | **0.00** | **0.11** | **0.08** | **0.08** | **0.03** | **0.19** | **0.23** | **0.03** | **5.56** | **0.35** | **5.56** |
| Plant 6 ISOU | 2,370 | EPC | 1.56 | 0.74 | 9.74 | 7.49 | 0.00 | 0.00 | 8.87 | 0.00 | 120.76 | 5.97 | 120.76 |
| Plant 6 Accessible | 29,965 | EPC | 0.25 | 0.00 | 0.26 | 0.20 | 0.00 | 0.13 | 2.33 | 0.00 | 16.05 | 0.87 | 16.05 |
| Plant 6 Total | 32,335 | **Combined EPC [c]** | **0.35** | **0.05** | **0.95** | **0.73** | **0.00** | **0.12** | **2.81** | **0.00** | **23.72** | **1.24** | **23.72** |
| ***Industrial Worker - Industrial/Commercial Vicinity Properties*** | | | | | | | | | | | | | |
| DT-2 ISOU | 12,665 | EPC | 0.00 | 0.00 | 2.05 | 1.58 | 0.01 | 0.07 | 0.90 | 0.00 | 1.45 | 0.14 | 1.45 |
| DT-2 Accessible | 77,475 | EPC | 0.15 | 0.00 | 0.01 | 0.01 | 0.00 | 0.08 | 2.94 | 0.00 | 1.48 | 0.10 | 1.48 |
| DT-2 Total | 90,140 | **Combined EPC [c]** | **0.13** | **0.00** | **0.30** | **0.23** | **0.00** | **0.08** | **2.65** | **0.00** | **1.48** | **0.11** | **1.48** |
| DT-4 ISOU | 7,962 | EPC | 9.40 | 9.04 | 8.89 | 6.84 | 0.12 | 0.23 | 63.48 | 0.14 | 82.02 | 4.54 | 82.02 |
| DT-4 Accessible | 6,178 | EPC | 0.15 | 0.02 | 0.52 | 0.40 | 0.01 | 0.06 | 1.97 | 0.00 | 10.86 | 0.62 | 10.86 |
| DT-4 Total | 14,140 | **Combined EPC [c]** | **5.36** | **5.10** | **5.23** | **4.02** | **0.07** | **0.16** | **36.60** | **0.08** | **50.93** | **2.83** | **50.93** |
| DT-6 ISOU | 3,582 | EPC | 6.72 | 6.29 | 2.95 | 2.27 | 0.00 | 0.13 | 23.36 | 0.00 | 24.67 | 1.46 | 24.67 |
| DT-6 Accessible | 6,686 | EPC | 0.08 | 0.00 | 0.06 | 0.05 | 0.00 | 0.37 | 1.99 | 0.03 | 2.70 | 0.26 | 2.70 |
| DT-6 Total | 10,268 | **Combined EPC [c]** | **2.40** | **2.19** | **1.07** | **0.82** | **0.00** | **0.29** | **9.45** | **0.02** | **10.36** | **0.68** | **10.37** |
| ***Industrial Worker - Railroad Properties*** | | | | | | | | | | | | | |
| DT-3 ISOU | 6,363 | EPC | 0.00 | 0.00 | 0.13 | 0.10 | 0.62 | 0.50 | 1.29 | 0.34 | 2.88 | 0.19 | 2.88 |
| DT-3 Accessible | 13,562 | EPC | 0.34 | 0.00 | 0.53 | 0.41 | 0.00 | 0.00 | 2.17 | 0.00 | 5.89 | 0.39 | 5.89 |
| DT-3 Total | 19,925 | **Combined EPC [c]** | **0.23** | **0.00** | **0.40** | **0.31** | **0.20** | **0.16** | **1.89** | **0.11** | **4.93** | **0.33** | **4.93** |
| DT-9 Rail Yard ISOU | 24,384 | EPC | 0.39 | 0.00 | 10.73 | 8.25 | 0.08 | 0.11 | 10.33 | 0.02 | 8.72 | 0.59 | 8.72 |
| DT-9 Rail Yard Accessible | 131,791 | EPC | 0.00 | 0.00 | 0.52 | 0.40 | 0.00 | 0.11 | 1.07 | 0.00 | 1.49 | 0.10 | 1.49 |
| DT-9 Rail Yard Total | 156,175 | **Combined EPC [c]** | **0.06** | **0.00** | **2.11** | **1.63** | **0.01** | **0.11** | **2.52** | **0.00** | **2.62** | **0.18** | **2.62** |
| DT-9 Main Line ISOU | 36,630 | EPC | 0.00 | 0.00 | 0.00 | 0.00 | 0.51 | 0.57 | 1.25 | 0.50 | 0.99 | 0.08 | 0.99 |
| DT-9 Main Line Accessible | 16,803 | EPC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.72 | 0.00 | 0.93 | 0.09 | 0.93 |
| DT-9 Main Line Total | 53,433 | **Combined EPC [c]** | **0.00** | **0.00** | **0.00** | **0.00** | **0.35** | **0.39** | **1.08** | **0.34** | **0.97** | **0.08** | **0.97** |

**Table K-15A. Property-Wide Exposure Point Concentrations for Radiological Contaminants of Potential Concern for Combined Inaccessible and Accessible Soil at Plant Properties, Industrial/Commercial Vicinity Properties, Railroad Properties and Roadways: Industrial Worker and Recreational User**

| Property | Area ($m^2$) | Statistic (pCi/g) | Radiological COPC (pCi/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ac-227 | Pa-231 | Pb-210 [a] | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | U-234 [a] | U-235 | U-238 |
| DT-9 Soil Spoils ISOU | 10,636 | EPC | 0.88 | 0.41 | 2.02 | 1.55 | 0.00 | 0.00 | 28.19 | 0.00 | 19.49 | 0.97 | 19.49 |
| DT-9 Soil Spoils Accessible | 68,230 | EPC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.66 | 0.00 | 1.06 | 0.12 | 1.06 |
| DT-9 Soil Spoils Total | 78,886 | **Combined EPC [c]** | **0.12** | **0.06** | **0.27** | **0.21** | **0.00** | **0.00** | **4.37** | **0.00** | **3.55** | **0.23** | **3.55** |
| DT-12 ISOU | 23,009 | EPC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.65 | 0.00 | 2.01 | 0.13 | 2.01 |
| DT-12 Accessible | 13,730 | EPC | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 2.49 | 0.00 | 3.45 | 0.22 | 3.45 |
| DT-12 Total | 36,739 | **Combined EPC [c]** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **2.59** | **0.00** | **2.55** | **0.16** | **2.55** |
| ***Industrial Worker - Roadways*** | | | | | | | | | | | | | |
| Angelrodt Street ISOU | 6,127 | EPC | 0.00 | 0.00 | 0.53 | 0.41 | 0.00 | 0.00 | 3.14 | 0.00 | 1.60 | 0.08 | 1.60 |
| Angelrodt Street Accessible | 2,816 | EPC | 0.33 | 0.66 | 0.82 | 0.63 | 0.00 | 0.00 | 1.76 | 0.00 | 3.35 | 0.27 | 3.35 |
| Angelrodt Street Total | 8,943 | **Combined EPC [c]** | **0.10** | **0.21** | **0.62** | **0.48** | **0.00** | **0.00** | **2.71** | **0.00** | **2.15** | **0.14** | **2.15** |
| Destrehan Street ISOU | 5,622 | EPC | 0.00 | 0.00 | 0.91 | 0.70 | 0.00 | 0.04 | 10.22 | 0.11 | 5.66 | 0.29 | 5.66 |
| Destrehan Street Accessible | 3,510 | EPC | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 5.55 | 0.00 | 1.72 | 0.13 | 1.72 |
| Destrehan Street Total | 9,132 | **Combined EPC [c]** | **0.03** | **0.00** | **0.56** | **0.43** | **0.00** | **0.06** | **8.43** | **0.07** | **4.15** | **0.23** | **4.15** |
| Hall Street ISOU | 2,274 | EPC | 0.64 | 0.00 | 2.21 | 1.70 | 0.00 | 0.00 | 4.17 | 0.00 | 6.98 | 0.42 | 6.98 |
| Hall Street Accessible | 4,473 | EPC | 0.83 | 0.00 | 5.51 | 4.24 | 0.00 | 0.16 | 5.22 | 0.03 | 10.30 | 0.67 | 10.30 |
| Hall Street Total | 6,747 | **Combined EPC [c]** | **0.77** | **0.00** | **4.40** | **3.38** | **0.00** | **0.11** | **4.87** | **0.02** | **9.18** | **0.59** | **9.18** |
| Mallinckrodt Street ISOU | 3,661 | EPC | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 | 0.60 | 0.22 | 5.63 | 0.39 | 5.63 |
| Mallinckrodt Street Accessible | 2,471 | EPC | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.27 | 0.41 | 0.00 | 0.65 | 0.05 | 0.65 |
| Mallinckrodt Street Total | 6,132 | **Combined EPC [c]** | **0.09** | **0.00** | **0.00** | **0.00** | **0.00** | **0.25** | **0.52** | **0.13** | **3.62** | **0.25** | **3.62** |
| North Second Street ISOU | 3,005 | EPC | 0.79 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 2.74 | 0.00 | 4.20 | 0.27 | 4.20 |
| North Second Street Accessible | 3,108 | EPC | 0.14 | 0.00 | 0.39 | 0.30 | 0.00 | 0.08 | 4.25 | 0.00 | 5.90 | 0.40 | 5.90 |
| North Second Street Total | 6,113 | **Combined EPC [c]** | **0.46** | **0.08** | **0.20** | **0.15** | **0.00** | **0.04** | **3.51** | **0.00** | **5.06** | **0.34** | **5.06** |

**Table K-15A. Property-Wide Exposure Point Concentrations for Radiological Contaminants of Potential Concern for Combined Inaccessible and Accessible Soil at Plant Properties, Industrial/Commercial Vicinity Properties, Railroad Properties and Roadways: Industrial Worker and Recreational User**

| Property | Area ($m^2$) | Statistic (pCi/g) | Radiological COPC (pCi/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ac-227 | Pa-231 | Pb-210 [a] | Ra-226 | Ra-228 | Th-228 | Th-230 | Th-232 | U-234 [a] | U-235 | U-238 |
| *Recreational User - St. Louis City Property (DT-2)* | | | | | | | | | | | | | |
| DT-2 Accessible | 77,475 | EPC | 0.15 | 0.00 | 0.01 | 0.01 | 0.00 | 0.08 | 2.94 | 0.00 | 1.48 | 0.10 | 1.48 |
| DT-2 Total | 90,140 | **Combined EPC [c]** | **0.13** | **0.00** | **0.30** | **0.23** | **0.00** | **0.08** | **2.65** | **0.00** | **1.48** | **0.11** | **1.48** |

[a] EPC was determined based upon table 2.15 of the Baseline Risk Assessment (DOE 1993)

[b] Background values were taken from Table 3-2 of the Background Soils Characterization Report for the St.Louis Downtown Site, St.Louis, Missouri (March 1999)

[c] Combined EPC is calculated as the area-weighted average of the ISOU (inaccessible) soil EPC and the accessible soil EPC.

# Table K-15B. Property-Wide Exposure Point Concentrations for Metal Contaminants of Potential Concern in Combined Inaccessible and Accessible Soil at Thomas and Proetz Lumber (DT-10): Industrial Worker

| CAS (Location) No. | Soil COPC | Inaccessible Soil | | Accessible Soil | | Entire Property | |
|---|---|---|---|---|---|---|---|
| | | EPC [a] (mg/kg) | Area ($m^2$) | EPC [b] (mg/kg) | Area ($m^2$) | EPC [c] (mg/kg) | Area ($m^2$) |
| **Thomas & Proetz Lumber (DT-10)** | | | | | | | |
| 7440-38-2 (DT10) | Arsenic | 1.63E+02 | 7.26E+02 | 4.67E+01 | 1.05E+04 | 5.42E+01 | 1.12E+04 |

[a] The inaccessible soil EPC presented is the 95% UCL for a gamma distribution.

[b] The accessible soil EPC presented is the maximum detected concentration because only two samples were collected from the accessible soil area.

[c] The Property EPC presented is the area-weighted average of the inaccessible and accessible soil EPCs.

## Table K-16A. Property-Wide Radiological Dose and Risk Characterization for Combined Inaccessible and Accessible Soil at Plant Properties and Industrial/Commercial Vicinity Properties: Industrial Worker

| Property | Total Dose/Risk | |
|---|---|---|
| | Max. Dose (mrem/yr) | Max. CR (unitless) |
| *Mallinckrodt Properties* | | |
| Plant 1 | 15 | **2.7E-04** |
| Plant 2 | 0.8 | 9.9E-06 |
| Plant 6 | 3 | **4.9E-05** |
| *Industrial/Commerical Vicinity Properties* | | |
| DT-2 (City of St. Louis Property) | 2 | **3.3E-05** |
| DT-4 (Gunther Salt) | **28** | **4.9E-04** |
| DT-6 (Heintz Steel) | 7 | **1.3E-04** |
| *Railroad Vicinity Properties* | | |
| DT-3 (Norfolk Southern Railroad) | 2 | **3.3E-05** |
| DT-9 (Terminal Railroad) Rail Yard | 4 | **6.7E-05** |
| DT-9 (Terminal Railroad) Main Line | 2 | **3.1E-05** |
| DT-9 (Terminal Railroad) Soil Spoils Area | 3 | **5.3E-05** |
| DT-12 (BNSF Railroad) | 2 | **2.9E-05** |
| *Roadways* | | |
| Angelrodt Street | 2 | **3.7E-05** |
| Destrehan Street | 6 | **1.0E-04** |
| Hall Street | 8 | **1.4E-04** |
| Mallinckrodt Street | 1 | **1.4E-05** |
| North Second Street | 2 | **4.2E-05** |

**Bold font** indicates that the CR is greater than the target of 1.0E-05. **Bold font** with gray shading indicates that the dose or COR is greater than the 25 mrem/yr benchmark or USEPA's highest target value of 1.0E-04, respectively.

**Table K-16B. Property-Wide Metals Risk Characterization for Combined Inaccessible and Accessible Soil at Thomas and Proetz Lumber (DT-10): Industrial Worker**

| Property/Location | Carcinogenic Effects | | Non-carcinogenic Effects | | EPC versus Background | | |
|---|---|---|---|---|---|---|---|
| | Total Property CR | Risk Driver COPC | Total Property HI | Risk Driver COPC | EPC (mg/kg) | Background (mg/kg) [a] | Is EPC > Background? |
| Thomas & Proetz Lumber (DT-10) [b] | 8.8E-06 | Arsenic | 5.5E-02 | NA | 5.42E+01 | 10.6 | Yes |

[a] Soil background value is the lesser of the 95% UCL and maximum detected value.

[b] The property EPC presented is the area-weighted average of the inaccessible and accessible soil EPCs.

CR = Cancer risk

HI = Hazard index

NA = Not Applicable

## Table K-17A. Property-Wide Radiological Dose and Risk Characterization for Inaccessible Soil at Railroads and Roadways: Construction Worker

| Property | Total Dose/Risk | |
|---|---|---|
| | Max. Dose (mrem/yr) | Max. CR (unitless) |
| ***Railroad Vicinity Properties*** | | |
| DT-3 (Norfolk Southern Railroad) | 1 | 6.4E-06 |
| DT-9 (Terminal Railroad) Rail Yard | 9 | 6.3E-06 |
| DT-9 (Terminal Railroad) Main Line | 1 | 7.7E-07 |
| DT-9 (Terminal Railroad) Soil Spoils Area | 9 | 6.3E-06 |
| DT-12 (BNSF Railroad) | 0.8 | 5.5E-07 |
| ***Roadways*** | | |
| Angelrodt Street | 1 | 7.5E-07 |
| Destrehan Street | 3 | 2.4E-06 |
| Hall Street | 2 | 1.4E-06 |
| Mallinckrodt Street | 0.5 | 3.9E-07 |
| North Second Street | 0.9 | 5.8E-07 |

# Table K-17B. Property-Wide Metals Risk Characterization for Inaccessible Soil at Railroads: Construction Worker

| Property/Location | Carcinogenic Effects | | Non-carcinogenic Effects | | EPC versus Background | | |
|---|---|---|---|---|---|---|---|
| | Total Property CR | Risk Driver COPC | Total Property HI | Risk Driver COPC | EPC (mg/kg) | Background (mg/kg) [a] | Is EPC > Background? |
| DT-9 Terminal RR Main Tracks [b] | 7.1E-11 | Cadmium | 7.0E-02 | Cadmium | 22.03 | 1.0 | Yes |
| DT-12 BNSF RR [c] | 6.2E-06 | Arsenic | 9.6E-01 | Arsenic | 166.8 | 10.6 | Yes |

[a] Soil background value is the lesser of the 95% UCL and maximum detected value.

[b] EPC is based on a 95% UCL for data collected between Mallinckrodt and Destrehan Streets.

[c] EPC is based on a 95% UCL for data collected adjacent to Plants 6 and 7.

CR = Cancer risk

HI = Hazard index

## Table K-18A. Radiological Dose and Risk Characterization for Inaccessible Soil Elevated Measurement Areas by Property: Utility Worker

| Property | Total Dose/Risk | |
|---|---|---|
| | Max. Dose (mrem/yr) | Max. CR (unitless) |
| ***Mallinckrodt Properties*** | | |
| Plant 1 Building 8 | 3 | 1.9E-06 |
| Plant 1 Building 25 | 0.1 | 9.6E-08 |
| Plant 1 Building 26 | 19 | **1.4E-05** |
| Plant 1 Building K Excavation Area | 3 | 1.9E-06 |
| Plant 1 SE Containment Pad | 1 | 7.1E-07 |
| Plant 1 Loading Dock | 1 | 5.6E-07 |
| Plant 1 Building X | 2 | 1.0E-06 |
| Plant 2 50 Series Excavation | 1 | 4.3E-07 |
| Plant 2 Southeast Corner | 1 | 9.90E-07 |
| Plant 2 Building 508 | 0.2 | 1.5E-07 |
| Plant 2 Building 510 | 0.1 | 8.0E-08 |
| Plant 6 Along Hall Street | 1 | 6.9E-07 |
| Plant 6 SW Corner | 4 | 2.5E-06 |
| ***Industrial/Commerical Vicinity Properties*** | | |
| DT-2 (City Property) Levee South Area | 1 | 4.8E-07 |
| DT-2 (City Property) Levee South of McKinley Bridge | 0.3 | 2.3E-07 |
| DT-4 (Gunther Salt North) Salt Domes | 11 | 6.9E-06 |
| DT-4 (Gunther Salt North) Southern Storage Building | 5 | 3.1E-06 |
| DT-4 (Gunther Salt North) Sidewalk | 1 | 3.8E-07 |
| DT-4 (Gunther Salt North) Admin/Warehouse | 0.4 | 2.5E-07 |
| DT-6 (Heintz Steel) Storage Building | 2 | 1.2E-07 |
| DT-6 (Heintz Steel) Western Edge of Storage Building | 1 | 7.7E-07 |
| DT-8 (PSC Metals, Inc.) RR Tracks Area 3 | 0.1 | 8.2E-08 |
| DT-8 (PSC Metals, Inc) RR Tracks Area 4 | 0.08 | 5.8E-08 |
| DT-8 (PSC Metals, Inc.) SE Corner of Warehouse | 2 | 1.1E-06 |
| ***Railroad Vicinity Properties*** | | |
| DT-3 (Norfolk Southern Railroad) Elevated Measurement Areas between Mallinckrodt and Angelrodt Streets | 1 | 6.8E-07 |
| DT-9 (Terminal Railroad) Main Tracks | 2 | 1.4E-06 |
| DT-9 (Terminal Railroad) Rail Yard | 4 | 2.9E-06 |
| DT-9 Terminal Railroad Soil Spoils Area | 2 | 1.1E-06 |
| DT-12 (BNSF RR) North of McKinley Bridge<br>DT-12 (BNSF RR) West Side of Tracks | 0.2 | 1.3E-07 |
| ***Roadways*** | | |
| North Second Street | 0.5 | 2.9E-07 |
| Hall Street | 0.5 | 3.1E-07 |
| Mallinckrodt Street | 0.2 | 1.6E-07 |
| Destrehan Street | 0.2 | 1.3E-07 |
| Angelrodt Street | 1 | 4.6E-07 |

**Bold font** indicates that the CR is greater than the target of 1.0E-05.

## Table K-18B. Metals Risk Characterization for Inaccessible Soil Elevated Measurement Areas by Property: Utility Worker

| Property/Location | Carcinogenic Effects | | Non-carcinogenic Effects | | EPC versus Background | | |
|---|---|---|---|---|---|---|---|
| | Total Property CR | Risk Driver COPC | Total Property HI | Risk Driver COPC | EPC (mg/kg) | Background (mg/kg) [a] | Is EPC > Background? |
| DT-9 Terminal RR [b] | 1.8E-11 | Cadmium | 1.8E-02 | Cadmium | 51.4 | 1.0 | Yes |
| Thomas & Proetz Lumber (DT-10) [c] | 5.8E-07 | Arsenic | 9.0E-02 | Arsenic | 139.9 | 10.6 | Yes |
| DT-12 BNSF RR [d] | 6.9E-07 | Arsenic | 1.1E-01 | Arsenic | 166.8 | 10.6 | Yes |

[a] Soil background value is the lesser of the 95% UCL and maximum detected value.

[b] EPC is based on a 95% UCL for data collected between Plants 2 and 6W.

[c] EPC is based on a 95% UCL for data collected around the Office Building.

[d] EPC is based on a 95% UCL for data collected adjacent to Plants 6 and 7.

CR = Cancer risk

HI = Hazard index

## Table K-19. Radiological Dose and Risk Characterization for Inaccessible Soil and Combined Inaccessible and Accessible Soil: Recreational User at the St. Louis City Property (DT-2)

| Property | Total Dose/Risk | |
|---|---|---|
| | Max. Dose (mrem/yr) | Max. CR (unitless) |
| *Industrial/Commerical Vicinity Properties* | | |
| DT-2 (City of St. Louis Property) Inaccessible Soil | < 0.1 | 1.2E-11 |
| DT-2 (City of St. Louis Property) Combined Inaccessible and Accessible Soil | < 0.1 | 5.4E-12 |

## Table K-20. Radiological Dose and Risk Characterization for Exterior Building Surfaces: Industrial Worker

| Property | Building | Dose (mrem/year) | CR |
|---|---|---|---|
| Plant 1 | Building 25 | < 0.1 | 5.70E-09 |
| DT-10 (Thomas and Proetz Lumber Company) | Wood Storage Building | 0.1 | 1.60E-08 |
| Cotto-Waxo Company (DT-14) | L-Shaped Building | < 0.1 | 2.50E-09 |

# Table K-21. Metals Risk Characterization for Sewer Sediment by Sampling Location: Sewer Maintenance Worker

| Sewer Sediment Sample Station ID | Description | Total Pathway CR [a] | Total Pathway HI [a] |
|---|---|---|---|
| McKinley Bridge (DT-11) - SLD123488 | Manhole MH-1 Just South of McKinley Bridge | 1.1E-07 | 6.7E-04 |
| Plant 1 - SLD123489 | Manhole Along Salisbury Street | 1.6E-07 | 1.7E-03 |
| Plant 1 - SLD123490 | Surface Drain North of Bldg. 3 | 3.5E-07 | 2.2E-03 |
| Plant 1 - SLD123492 | Surface Drain MH-56 | 1.4E-07 | 8.7E-04 |
| Plant 1 - SLD123493 | Surface Drain MH-55 | 1.9E-07 | 1.2E-03 |
| Plant 1 - SLD123494 | Manhole MH-58 | 1.2E-07 | 7.2E-04 |
| Plant 1 - SLD123495 | Surface Drain Approx. 30 feet from the Southwest corner of Bldg. G | 7.4E-08 | 4.6E-04 |
| Plant 1 - SLD123496 | Surface Drain in the Center of Bldgs. B, C, 10, F, and G | 4.7E-07 | 2.9E-03 |
| Plant 1 - SLD123498 | Surface Drain MH-66 | 7.7E-08 | 4.8E-04 |
| Plant 2 - SLD123740 | Surface Drain MH-51 West of Former 50-Series Bldgs. | 5.2E-08 | 3.3E-04 |
| Plant 2 - SLD123743 | Manhole MH-37 | 4.7E-08 | 2.9E-04 |
| Plant 2 - SLD123744 | Manhole MH-39 South of Plant Along Destrehan Street | 5.8E-08 | 3.6E-04 |
| Plant 6 - SLD123748 | Plant 2/Surface Drain MH-30 East of Plant Along DT-9 (Terminal Railroad) | 7.2E-08 | 4.5E-04 |
| Plant 2 - SLD123749 | Surface Drain North of Bldg 502 | 3.6E-08 | 2.2E-04 |
| Plant 2 - SLD123750 | Curb Drain Outside of Plant Along North Second Street | 7.7E-08 | 4.8E-04 |

[a] Total CR and HI values presented for each location represent the sum of CR and HI values determined for ingestion and dermal exposures to sediment by the sewer maintenance worker.

CR = Cancer risk

EPC = Exposure point concentration represented by individual sample result.

HI = Hazard index

## Table K-22A. Radiological Dose and Risk Characterization for Inaccessible Soil Adjacent to Sewer Lines by Property/Borehole Location: Sewer Utility Worker

| Property | Total Dose/Risk | |
|---|---|---|
| | Max. Dose (mrem/yr) | Max. CR (unitless) |
| ***Mallinckrodt Properties*** | | |
| Plant 1 - SLD124540 | 1 | 5.5E-07 |
| Plant 6 - HTZ88929, HTZ88930 | 15 | **1.1E-05** |
| ***Industrial/Commerical Vicinity Properties*** | | |
| DT-2 (City Property), Sewer Line beneath the Levee [a] | **31** | **2.3E-05** |
| ***Railroad Vicinity Properties*** | | |
| Plant 7N/BNSF Railroad (DT-12) Sewer Line Excavation [b] | **259** | **1.9E-04** |

[a] Samples SLD120945, SLD120946, SLD120947, SLD120948

[b] Samples SLD93275, SLD93276, SLD93277

**Bold font** indicates that the CR is greater than the target of 1.0E-05. Bold font with gray shading indicates that the dose or COR is greater than the 25 mrem/yr benchmark or USEPA's highest target value of 1.0E-04, respectively.

## Table K-22B. Metals Risk Characterization for Inaccessible Soil Adjacent to Sewer Lines by Borehole Location: Sewer Utility Worker

| Sewer Borehole Location [a] | Description Relative to Sediment Locations | Total Location CR [a] | Total Location HI [a] |
|---|---|---|---|
| Plant 1 - SLD124540 | Approximately 30 ft east and downstream of surface drain location SLD123495. | 5.4E-07 | 9.5E-02 |
| Plant 1 - SLD124546 | Located outside of northwest plant boundary along Salisbury St.; downstream of surface drain location SLD123492 (MH-56). | 2.5E-07 | 3.9E-02 |
| Plant 1 - SLD124548 | Located adjacent to surface drain SLD123491 (MH-59), northwest of Bldg. 10. | 6.2E-10 | 6.1E-01 |
| Plant 1 - SLD124554 | Located approx. 60 ft to the east and downstream of surface drain SLD123491 (MH-59); just northeast of Bldg. 10. | 1.0E-11 | 1.0E-02 |
| Plant 1 - SLD125521 | Located approx. 30 ft to the north and downstream of surface drain MH-46 (not sampled), and upstream (south) of surface drain SLD123491 (MH-59). | 1.0E-11 | 1.0E-02 |
| Plant 6 - SLD124586 | Located outside of northeast corner of Plant 7N, adjacent to BNSF RR (DT-12). | 6.1E-12 | 6.1E-03 |

[a] Borehole location selected based on exceedances of industrial screening levels. EPCs are based on the maximum detection at each borehole.

CR = Cancer risk

HI = Hazard index

# APPENDIX L

## Data: Radiological and Metals Analytical Data Summaries for Accessible Soil by Property

## (On the CD-ROM on the Back Cover of this Report)

# APPENDIX M

## Exposure Point Concentration Calculations for Radiological COPCs

## (On the CD-ROM on the Back Cover of this Report)

# APPENDIX N

## Exposure Point Concentration Calculations for Metal COPCs

## (On the CD-ROM on the Back Cover of this Report)

# APPENDIX O

## RESRAD Model Outputs: Radiological Dose and Risk Calculations for Inaccessible Soil and Sewer Soil Borehole Locations

**(On the CD-ROM on the Back Cover of this Report)**

# APPENDIX P

## RESRAD-BUILD Model Outputs: Radiological Dose and Risk Calculations for Exterior Building Surfaces

**(On the CD-ROM on the Back Cover of this Report)**

# APPENDIX Q

## Dose and Risk Calculations for Exposures to Metals COPCs in Inaccessible Soil, Sewer Sediment, and Soil Adjacent to Sewer Lines

**(On the CD-ROM on the Back Cover of this Report)**

# APPENDIX R

## Ecological Checklist for SLDS ISOU

# Checklist for Ecological Assessment/Sampling

## I. SITE DESCRIPTION

1. **Site Name:** Inaccessible Soil Operable Unit (ISOU) at SLDS

   **U.S. EPA ID Number:** MOD980633176

   **Location:** Site is roughly bounded by Dock Street, Ninth Street, Angelica Street, and the Mississippi River.

   **County:** NA **City:** St. Louis **State:** Missouri

2. **Latitude:** 38-39-44 N **Longitude:** 90-11-21 W

3. **Attach site maps, including a topographical map, a diagram which illustrates the layout of the facility (e.g. site boundaries, structures, etc.), and maps showing all habitat areas identified in Section III of the checklist. Also, include maps which illustrate known and suspected release area, sampling location and any other important features, if available.** See Figures R-1,R-2, and R-3.

## II. SITE CHARACTERIZATION

1. **What is the approximate area of the site?**

   Site is approximately 210 acres.

2. **Is this the first site visit?** ☒ **Yes** ☐ **No**
   **If no, attach trip report of previous site visit(s), if available.**

   **Date(s) of previous site visit(s):**

3. **Are aerial or other site photographs available?** ☒ **Yes** ☐ **No**
   **If yes, please attach any available photo(s) to the site map at the conclusion of this section.**
   See attached photographs.

4. **The land use on the site is:**

| | | |
|---|---|---|
| **50 % Heavy Industrial** | **48 % Light Industrial** | **% Urban** |
| **% Residential** | **% Rural** | **% Agricultural[b]** |
| **2 % Recreational[a]** | **% Undisturbed** | **% Other[c]** |

   **[a]For recreational areas, please describe the use of the area (e.g., park, playing field, etc)**
   The Riverfront Bike trail extends along the east side of the property. The bike trail is a paved trail that is located on a levee in the northern portion of the site and then drops into the floodplain area located between the levee and the Mississippi River in the southern portion of the site (See Photos 34 and 35).

   **[b]For agricultural areas, please list the crops and /or livestock which are present**

   **[c]For areas designated as "other," please describe the use of the area**

5. **Provide an approximate breakdown of land uses in the areas surrounding the site. Indicate the radius (in miles) of the area described:** 1- mile radius from the approximate center of the Mallinckrodt property.

| | | |
|---|---|---|
| **40 % Heavy Industrial** | **28 % Light Industrial** | **% Urban** |
| **7 % Residential** | **% Rural** | **% Agricultural[b]** |
| **% Recreational[a]** | **% Undisturbed** | **25 % Other[c]** |

   **[a]For recreational areas, please describe the use of the area (e.g., park, playing field, etc)**

   **[b]For agricultural areas, please list the crops and /or livestock which are present**

   **[c]For areas designated as "other," please describe the use of the area** – Mississippi River

6. **Has any movement of soil taken place at the site? ☒ Yes ☐ No.**
**If yes, please identify the most likely cause of this disturbance:**

☐ Agricultural Use ☐ Heavy Equipment ☐ Mining ☐ Erosion ☐ Natural Events ☒ Other
**Please describe:** The project site has been continuously occupied since the early 1800's. Construction and land alteration has occurred throughout the history of site as a variety of structures have been built and then demolished. The construction of the levees involved a large addition of fill material to the site. In addition, numerous remediation activities have occurred at the site removing contaminated soils and replacing those soils with clean fill.

7. **Do any potentially sensitive environmental areas exist adjacent to or in proximity to the site (e.g., Federal and State parks, National and State monuments, wetlands, prairie potholes)? *Remember, flood plains and wetlands are not always obvious; do not answer "no" without confirming information.*** No. The Mississippi River is located adjacent to the site. The river is channelized at this location and flow is primarily confined to the navigation channel. A small area of the site is located with the 100-year floodplain of the Mississippi River. The majority of the site is protected by a levee along the eastern edge of the site. National Wetland Inventory Maps from the 1980's indicate that a small forested wetland is located along the river just north of the McKinley bridge. This wetland was not observed during the field reconnaissance. No other wetlands were observed at the site.

**Please provide the source(s) of information used to identify these sensitive areas, and indicate their general location on the site map.**

8. **What type of facility is located at the site?**

☒ Chemical ☒ Manufacturing ☐ Mixing ☐ Waste disposal

☒ Othcr (spccify): The primary site is the Mallinckrodt property, which began in 1867 with the construction of a chemical plant. Operations have continued at this site since 1867. From 1942 to 1957, Mallinckrodt processed uranium feed materials in support of the nation's early nuclear program.

9. **What are the suspected contaminants of concern at the site? If known, what are the maximum concentration levels? Please cite the source of data cited (e.g. RFI, confirmatory sampling, etc.).**
Contaminants of concern include: arsenic, cadmium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, thorium, uranium, vanadium, and zinc. Radiological constituents include Ra-226, Ra-228, Th-230, Th-232, U-234, U-235, U-238, Ac-227, Pb-210, and Pa-231. Additional details for contaminants of concern can be found in the Remedial Investigation Report.

10. **Check any potential routes of off-site migration of contaminants observed at the site:**

☐ Swales ☐ Depressions ☐ Drainage ditches

☐ Runoff ☐ Windblown particulates ☐ Vehicular traffic

☒ Other (specify): There appears to be very little opportunity for off-site migration through surface water. The majority of the site is covered by buildings, parking lots, or other pavement. Storm water at the site is collected by storm sewers and discharges to a sanitary sewer. Since most of the soils at the site are covered windblown contamination is also unlikely.

11. **If known, what is the approximate depth to the water table?**
7-32' below ground surface

12. **Indicate the direction of ground-water flow.**
Ground-water flow is generally to the east.

13. **Is the direction of surface runoff apparent from site observations? ☒ Yes ☐ No**
**If yes, to which of the following does the surface runoff discharge? Indicate all that apply.**

☐ Surface water ☐ Ground water ☒ Sewer ☐ Collection impoundment

Stormwater on the site is collected in a series of swales and curb and drop inlets and then conveyed offsite to wastewater treatment facilities.

14. **Is there a navigable waterbody or tributary to a navigable waterbody? ☒ Yes ☐ No**
The Mississippi River is located adjacent to the site.

15. **Is there a water body on or in the vicinity of the site? If yes, also complete Section III.B.1: Aquatic Habitat Checklist -- Non-Flowing Systems and/or Section III.B.2: Aquatic Habitat Checklist -- Flowing Systems.**

**☐ Yes ☒ No**

16. **Is there evidence of flooding? ☐ Yes ☒ No**
*Wetlands and flood plains are not always obvious; do not answer "no" without confirming information.* **If yes, complete Section V: Wetland Habitat Checklist.** No visible evidence of flooding or wetlands was observed at the site. The eastern portion of the site is located within the 100-year floodplain of the Mississippi River; however, it does not appear that floodwaters have reached the site in some time. The lack of potential wetlands and floodplains was confirmed by an SAIC wetland scientist during the site visit.

17. **If a field guide was used to aid any of the identifications, please provide a reference. Also, estimate the time spent identifying fauna. [Use a blank sheet if additional space is needed for text.]** Not applicable

18. **Are any threatened and/or endangered species (plant or animal) known to inhabit the area of the site?**
**☐ Yes ☒ No**
*If yes, you are required to verify this information with the U.S. Fish and Wildlife Service.* **If species' identities are known, please list them next.**

19. **Record weather conditions at the time this checklist was prepared:**

**DATE:** 09/10/2010

**Temperature:** 80° F

**Normal daily high temperature:** 83° F

**Wind (direction/speed):** None

**Precipitation (rain, snow):** <0.1 inches

**Cloud cover:** Overcast, occasional light rain

20. **Describe reasonable and likely future land and/or water use(s) at the site.**
The project site is located within a highly industrialized portion of the City of St. Louis. There are no known plans to discontinue the use of the Mallinckrodt facility. Therefore the site is anticipated to remain as industrial land use.

No surface water is located at the site. The use of ground water for potable water is prohibited by the City of St. Louis.

21. **Describe the historical uses of the site. Include information on chemical releases that may have occurred as a result of previous land uses. For each chemical release, provide information on the form of the chemical released (i.e., solid, liquid, vapor) and the known or suspected causes or mechanism of the release (i.e., spills, leaks, material disposal, dumping, explosion, etc.).**
Detailed information concerning site history may be found in the Remedial Investigation Report.

22. **Identify the media (e.g., soil [surface or subsurface], surface water, air, ground water) which are known or suspected to contain COCs.**
Contamination is suspected in inaccessible soil and sediments associated with buildings and sewers, roadwayS, and railroads.

## IIA. SUMMARY OF OBSERVATIONS AND SITE SETTING

**Include information on significant source areas and migration pathways that are likely to constitute complete exposure pathways.**

The site visit began at approximately 0930 on 09/10/10 with overcast skies and a temperature of 80° F. Observations were made within the boundaries of the SLDS property. Areas adjacent to SLDS were observed from the public roadways.

SLDS is predominantly an industrialized area and the only habitat present at the site consists of small wooded areas and barren/field habitats. The wooded areas are located at three main areas (DT-2, DT-5, and DT-9) as shown in Figure R-2. Open field areas are located along the levee (DT-9), at DT-1 and the Terminal Railroad Spoil Area. The largest vegetated area on the site is the area adjacent to the Mississippi River along the levee. The majority of this area is maintained as mowed turfgrass. A highly disturbed, linear forested area is located immediately adjacent to the Mississippi River. This approximately 4.5 acre fragmented woodland is dominated by disturbance-tolerant species such as mulberry (*Morus* sp.), eastern cottonwood (*Populus deltoides*), Amur honeysuckle (*Lonicera maackii*), and Japanese honeysuckle (*Lonicera japonica*). A few American sycamore (*Platanus occidentalis*) and silver maple (*Acer saccharinum*) trees Are also present. There is almost no understory present in the woodland.

Other large, vegetated areas at the site include a small wooded area adjacent to the Terminal railroad tracks, a wooded area adjacent to the Ameren UE electrical station (DT-5), and a former building site (DT-1). All of these areas are characterized by disturbance-tolerant species such as tree of heaven (*Ailanthus altissma*), Amur honeysuckle, Johnson grass (*Sorghum halepense*), and ragweed (*Ambrosia artemisiifolia, A. trifida*). These areas are described in more detail in Section IIIA1 and IIIA3.

Wildlife observations during the site visit included several bird species (swallow, sparrow, robin, cardinal, mourning dove, and mockingbird) as well as a groundhog den, raccoon tracks, and beaver cuttings.

There are no complete significant exposure pathways to ISOU media being evaluated in the ISOU RI Report (inaccessible soil, storm sewer sediment, and structural surfaces) at the site. There is no natural ecological habitat at the site. Few terrestrial receptors are likely to inhabit the site because the patchiness of the vegetation, lack of cover and water, and high level of disturbance are unattractive to wildlife. The only receptors likely to use the site would be urban-adapted species. Finally, there is no evidence of significant ground-water migration offsite to more sensitive aquatic habitats.

**Completed by:** Brian W. Tutterow **Affiliation:** SAIC

**Date:** 09/10/2010

# III. HABITAT EVALUATION

## IIIA. Terrestrial Habitat Checklist

### IIIA1. WOODED

1. **Are there any wooded areas at the site?** ☒ **Yes** ☐ **No**
   **If no, go to Section IIB: Shrub/Scrub.**

   **Wooded Area Questions**

   ☒ Onsite ☐ Offsite

**Name or Designation:** Wooded Area 1 (DT-2); Figure R-2, Photographs 1-4

1. **Estimate the approximate size of the wooded area** (4.5 acres)
   **Please identify what information was used to determine the wooded area of the site (e.g., direct observation, photos, etc).** Aerial photography and direct observation

2. **Indicate the dominant type of vegetation in the wooded area. Provide photographs, if available.**

   ☐ Evergreen
   ☒ Deciduous
   ☐ Mixed

   **Dominant plant species, if known:** Species underlined were dominant
   **Tree and Shrub Layer:** Mulberry, cottonwood, Amur honeysuckle, sumac, (*Rhus* sp.), silver maple, black willow (*Salix nigra*), black locust (*Robinia pseudoacacia*), Siberian elm (*Ulmus pumila*).

3. **Estimate the vegetation density of the wooded area.**

   ☒ **Dense (i.e., greater than 75% vegetation)**
   ☐ **Moderate (i.e., 25% to 75% vegetation)**
   ☐ **Sparse (i.e., less than 25% vegetation)**

4. **Indicate the predominant size of the trees at the site. Use diameter at breast height.**

   ☐ **0-6 inches**
   ☒ **6-12 inches**
   ☐ **>12 inches**
   ☐ **No single size range is predominant**

5. **Specify type of understory present, if known. Provide a photograph, if available.**
   Honeysuckle was the only understory species present. The following species were present in the unmowed areas adjacent to the woods: Johnson grass, foxtail (*Setaria glauca*), goldenrod (*Solidago* sp.), late flowering thoroughwort (*Eupatorium serotinum*), elderberry (*Sambucus canadensis*).

<u>**Name or Designation:** Wooded Area 2 (DT-5); Figure R-2, Photographs 4-8</u>

**Estimate the approximate size of the wooded area** (0.5 acres)

**Please identify what information was used to determine the wooded area of the site (e.g., direct observation, photos, etc).** Aerial photography and direct observation

1. **Indicate the dominant type of vegetation in the wooded area. Provide photographs, if available.**

   ☐ Evergreen
   ☒ Deciduous
   ☐ Mixed

   **Dominant plant species are underlined:** <u>cottonwood, tree of heaven,</u> sycamore, black locust, Catalpa (*Catalpa speciosa*)

2. **Estimate the vegetation density of the wooded area.**

   ☒ **Dense (i.e., greater than 75% vegetation)**
   ☐ **Moderate (i.e., 25% to 75% vegetation)**
   ☐ **Sparse (i.e., less than 25% vegetation)**

3. **Indicate the predominant size of the trees at the site. Use diameter at breast height.**

   ☒ **0-6 inches**
   ☐ **6-12 inches**
   ☐ **>12 inches**
   ☐ **No single size range is predominant**

4. **Specify type of understory present, if known. Provide a photograph, if available.**
   Understory was limited to Amur honeysuckle with some horseweed (*Conyza canadensis*), ragweed, and late flowering thoroughwort along the edges of the woods.

<u>**Name or Designation:** Wooded Area 3 (DT-9); Figure R-3, Photographs 9-12</u>

1. **Estimate the approximate size of the wooded area** (1.0 acres)
   **Please identify what information was used to determine the wooded area of the site (e.g., direct observation, photos, etc).** Aerial photography and direct observation

2. **Indicate the dominant type of vegetation in the wooded area. Provide photographs, if available.**

   ☐ Evergreen
   ☒ Deciduous
   ☐ Mixed

   **Dominant plant species are underlined:** <u>Mulberry, Siberian elm, tree of heaven,</u> sycamore, wild grape, cottonwood, hackberry

3. **Estimate the vegetation density of the wooded area.**

   ☒ **Dense (i.e., greater than 75% vegetation)**
   ☐ **Moderate (i.e., 25% to 75% vegetation)**
   ☐ **Sparse (i.e., less than 25% vegetation)**

4. **Indicate the predominant size of the trees at the site. Use diameter at breast height.**

   ☒ **0-6 inches**
   ☐ **6-12 inches**
   ☐ **>12 inches**
   ☐ **No single size range is predominant**

5. **Specify type of understory present, if known. Provide a photograph, if available.**
The understory was limited to Amur honeysuckle. Some scattered camphorweed (*Heterotheca subaxillaris*) and annual sunflower (*Helianthus annuus*) as well as a few large clusters of Johnson grass were present in the gravel area adjacent to the woods.

**IIIA2. SHRUB/SCRUB**

1. **Is shrub/scrub vegetation present at the site?** ☐ **Yes** ☒ **No**
**If no, go to Section IIC: Open Field.**
The remainder of Section IIIA2 is not applicable

**IIIA3. OPEN FIELD**

1. **Are there open (bare, barren) field areas present at the site?** ☒ **Yes** ☐ **No**
**If yes, please answer the questions below:**

**Open Field Area Questions**

☒ Onsite ☐ Offsite

**Name or Designation:** Field 1 (Plant 7E, DT-1); Photographs 13-20

1. **Estimate the approximate size of the open field area.** 7.0 acres
**Please identify what information was used to determine the open field area of the site.** Aerial photography and direct observation.

2. **List the vegetation: (dominant vegetation is underlined).**
Field 1A: Johnson grass, common ragweed, common sunflower, evening primrose (*Oenothera biennis*), purple top (*Tridens flavus*), foxtail, partridge pea (*Chamaecrista fasiculata*), common mullein (*Verbascum thapsus*), cottonwood
Field 1B: Johnson grass, foxtail, common ragweed, late flowering thoroughwort, cottonwood, common sunflower, spotted spurge (*Euphorbia maculate*), goldenrod, common mullein, horseweed

3. **Estimate the vegetation density of the area.**

☐ **Dense (i.e., greater than 75% vegetation)**
☒ **Moderate (i.e., 25% to 75% vegetation)**
☐ **Sparse (i.e., less than 25% vegetation)**

4. **Indicate the approximate average height of the dominant plant:** cottonwoods on the edge of the Field 1A were approximately 8-10 feet tall, several cottonwoods were that tall in Field 1B and a single tree near the center of the site was ~25 feet tall. Sunflowers in the interior of both sites were approximately 3 feet tall.

**Name or Designation:** Field 2 (DT-9); Photographs 21-24

1. **Estimate the approximate size of the open field area.** 13 acres
**Please identify what information was used to determine the open field area of the site.** Aerial photographs and site observation.

2. **List the vegetation: (dominant vegetation is underlined).**
Common ragweed, foxtail, Johnson grass, wormwood (*Artemisia* sp.), spiny amaranth (*Amaranthus spinosus*), chicory (*Cichorium intybus*), red clover (*Trifolium pretense*)

3. **Estimate the vegetation density of the area.**

☐ **Dense (i.e., greater than 75% vegetation)**
☒ **Moderate (i.e., 25% to 75% vegetation)**
☐ **Sparse (i.e., less than 25% vegetation)**

4. **Indicate the approximate average height of the dominant plant:** 5-6 feet

**Name or Designation:** Field 3 (Terminal Railroad Spoil Area); Photographs 25-27

1. **Estimate the approximate size of the open field area.** 5.75 acres
**Please identify what information was used to determine the open field area of the site.**

2. **List the vegetation: (dominant vegetation is underlined).**

Common sunflower, late flowering thoroughwort, camphorweed, Johnson grass, horseweed, mulberry, common mullein, goldenrod, Chinese lespedeza, (*Lespedeza cuneata*), Queen Anne's lace (*Daucus carota*), common ragweed.

3. **Estimate the vegetation density of the area.**

☐ **Dense (i.e., greater than 75% vegetation)**
☒ **Moderate (i.e., 25% to 75% vegetation)**
☐ **Sparse (i.e., less than 25% vegetation)**

4. **Indicate the approximate average height of the dominant plant:** 3-4 feet

**IIIA4. MISCELLANEOUS**

1. **Are other types of terrestrial habitats present at the site, other than woods, scrub/shrub, and open field?**
☒ **Yes** ☐ **No**
**If yes, identify and describe them below.**

2. **Describe the terrestrial miscellaneous habitat(s) and identify these area(s) on the site map.**
Areas of vegetation less than 0.1 acres in size are scattered throughout the SLDS along fence lines and in the corners of unused lots. In total, it is estimated that these sites total less than 1.5 acres of additional habitat. Vegetation in these areas is characterized by noxious and invasive species such as Johnson grass, ragweed, mulberry, Amur honeysuckle, and tree of heaven. A few sites contained cottonwoods and sumac. See photographs 32-33.

3. **What observations, if any, were made at the site regarding the presence and/or absence of insects, fish, birds, mammals, etc.?**
Several species of birds were observed at the site including swallow, mourning dove, mockingbird, robin, cardinal, American goldfinch, and sparrows. Raccoon tracks were observed along the Mississippi River and a ground hog den was observed in Wooded Area 2. Evidence of beaver cuts on trees were also observed in the wooded area adjacent to the river. An eastern cottontail rabbit was observed in Field 3.

4. **Review the questions in Section I to determine if any additional habitat checklists should be completed for this site.**
No other habitat type is applicable.

## III.B AQUATIC HABITAT

### III.B1 NON-FLOWING SYSTEMS

1. **What type of open-water, non-flowing system is present at the site?** None

   The remainder of Section IIIB1 is not applicable.

### III.B2 FLOWING SYSTEMS

1. **What type(s) of flowing water system(s) is (are) present at the site?** The Mississippi River is located adjacent to the site.

   **Flowing Aquatic Systems Questions**

   ☐ Onsite ☒ Offsite

<u>Name or Designation:</u> <u>Mississippi River</u> – the river is not considered part of the site although it is possible that during a 100-year flood event portions of the site east of the levee (DT-2, DT-9, DT-15) would be flooded. See Photographs 28-31.

**Indicate the type of flowing aquatic feature present.** River

1. **For natural systems, are there any indicators of physical alteration (e.g., channeling, debris, etc.)?**
   ☐ Yes ☒ No
   **If yes, please describe the indicators observed.**
   The river has been extensively modified through the use of dams, dredging, levees, wing dams, and rip-rap. Most of the river bank adjacent to the site has at least some remaining rip-rap structure.

2. **Indicate the general composition of the bottom substrate.**

| | | |
|---|---|---|
| ☐ **Bedrock** | ☐ **Sand (course)** | ☐ **Concrete** |
| ☐ **Boulder (>10 in.)** | ☒ **Silt (fine)** | ☒ **Debris** |
| ☐ **Cobble (2.5 - 10 in.)** | ☐ **Clay (slick)** | ☒ **Detritus** |
| ☐ **Gravel (0.1 - 2.5 in.)** | ☒ **Muck (fine/black)** | ☐ **Marl (Shells)** |

   ☐ **Other (please specify):**______________________________

3. **Describe the condition of the bank (e.g., height, slope, extent of vegetative cover).**
   The bank is generally steep and at the time of the survey extended approximately 15-20 feet above the waterlevel of the river. The bank was un-vegetated and consisted of a mix of rip-rap and silt.

4. **Is the system influenced by tides?** ☐ **Yes** ☒ **No**
   **What information was used to make this determination?**

5. **Is the flow intermittent?** ☐ **Yes** ☒ **No**
   **If yes, please note the information used to make this determination.**
6. **Is there a discharge from the site to the water body?** ☐ **Yes** ☒ **No**
   **If yes, describe the origin of each discharge and its migration path.**

7. **Indicate the discharge point of the water body. Specify name of the discharge, if known.**

8. **Identify any field measurements and observations of water quality that were made. Provide the measurement and the units of measure in the appropriate space below:**
No water quality measurements were made.

9. **Describe observed color and area of coloration.**
No color observations were made.

10. **Is any aquatic vegetation present?** ☐ **Yes** ☒ **No**
**If yes, please identify the type of vegetation present, if known.**

☐ **Emergent** ☐ **Submergent** ☐ **Floating**

11. **Mark the flowing water system on the attached site map.**
See attached Figures R-1 and R-2.

12. **What observations were made at the water body regarding the presence and/or absence of benthic macroinvertebrates, fish, birds, mammals, etc?** Evidence of birds (swallow, mourning dove), beaver, and raccoon were observed at the site.

## IIIC. WETLAND HABITAT CHECKLIST

1. Are any wetland[1] areas such as marshes or swamps on or adjacent to the site?
☐ **Yes** ☒ **No**

**Identify the sources of the observations and information (e.g., National Wetland Inventory, Federal or State Agency, USGS topographic maps) used to make the determination whether or not wetland areas are present.**
The lack of wetlands on site was made after a review of National Wetland Inventory maps, aerial photographs, and an on-site visit by an SAIC wetland scientist.

**If no wetland areas are present, proceed to Section III.D: Sensitive Environments and Receptors.**

## III.D Sensitive Environments and Receptors

1. **Do any other potentially sensitive environmental areas[2] exist adjacent to or within one-half mile of the site? If yes, list these areas and provide the source(s) of information used to identify sensitive areas. Do not answer "no" without confirmation from the U.S. Fish and Wildlife Service and other appropriate agencies. See Table 1 for a list of contacts.**
No. The project is located with an industrial urban area with no potential for sensitive environmental areas. The Missouri Department of Conservation's Natural Heritage database indicated that no threatened or endangered species are known to occur in the City of St. Louis.

2. **Are any areas on or near (i.e., within one-half mile) the site owned or used by local tribes? If yes, describe.**
No

[1]Wetlands are defined in 40 CFR §232.2 as " Areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Examples of typical wetlands plants include: cattails, cordgrass, willows and cypress trees. National wetland inventory maps may be available at http:\\nwi.fws.gov. Additional information on wetland delineation criteria is also available from the USACE.

[2] Areas that provide unique and often protected habitat for wildlife species. These areas are typically used during critical life stages such as breeding, hatching, rearing of young and overwintering. Refer to Table 2 at the end of this document for examples of sensitive environments.

3. **Does the site serve or potentially serve as a habitat, foraging area or refuge by rare, threatened, endangered, candidate and/or proposed species (plants or animals), or any otherwise protected species? If yes, identify species. This information should be obtained from the U.S. Fish and Wildlife Service and other appropriate agencies. See Table 1 for a list of contacts.**
   No suitable habitat is present on site.

4. **Is the site potentially used as a breeding, roosting or feeding area by migratory bird species? If yes, identify which species.**
   The site could provide limited habitat to urban-adapted migratory bird species such as robins.

5. **Is the site used by any ecologically[3], recreationally or commercially important species? If yes, explain.**
   No, the limited habitat quality and quantity on the site would only be suitable for species adapted to urban habitat.

## IV. EXPOSURE PATHWAY EVALUATION

**Do existing data provide sufficient information on the nature, rate and extent of contamination at the site?**

**Yes**
**No**
**Uncertain**

1. **Please provide an explanation for your answer.** Numerous studies have been conducted on site including the 1977 radiological survey, the 1987-1990 Phase 1 and Phase 2 site characterization, a remedial investigation addendum in 1992-1993, the 1998 background soil survey, and the ongoing pre-design investigations and final status survey evaluations. Details of these investigations are included in the Remedial Investigation Work Plan for the Inaccessible Soil Operable Unit at the SLDS.

2. **Do existing data provide sufficient information on the nature, rate and extent of contamination in offsite affected areas?**

   **Yes**
   **No**
   **Uncertain**
   **No offsite contamination**

   **Please provide an explanation for your answer:** Observation of site conditions including ground-water flow and the impervious nature of the majority of the site surface limit potential for offsite contamination.

3. **Do existing data address potential migration pathways of contaminants at the site?**

   **Yes**
   **No**
   **Uncertain**

   **Please provide an explanation for your answer.** The majority of potential site contaminants occur within accessible soils at the site which are under remediation. Migration of contaminants from inaccessible soil is limited since most of these soils are covered by buildings, pavement or other impervious materials.

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[3] Ecologically important species include populations of species which provide a critical (i.e., not replaceable) food resource for higher organisms. These species' functions would not be replaced by more tolerant species or perform a critical ecological function (such as organic matter decomposition) and will not be replaced by other species. Ecologically important species include pests and opportunistic species that populate an area <u>if they serve as a food source for other species</u>, but do <u>not</u> include domesticated animals (e.g., pets and livestock) or plants/animals whose existence is maintained by continuous human interventions (e.g., fish hatcheries, agricultural crops, etc).

4. **Do existing data address potential migration pathways of contaminants in offsite affected areas?**

**Yes**
**No**
**Uncertain**
**No offsite contamination**

**Please provide an explanation for your answer.** See response to question 2 above.

5. **Are there visible indications of stressed habitats or receptors on or near (i.e., within one-half mile) the site that may be the result of a chemical release? If yes, explain. Attach photographs if available.** No

6. **Is the location of the contamination such that receptors might be reasonably expected to come into contact with it? For soil, this means contamination in the soil 0 to 1 foot below ground surface (bgs). If yes, explain.** Contamination may be present within the inaccessible soil at the site. The potential that receptors could come in contact with this soil is unlikely due to the presence of buildings, roadways, etc. acting as cover material. Additionally, the presence of potential receptors is limited by the quality and quantity of available habitat on site.

7. **Are receptors located in or using habitats where chemicals exist in air, soil, sediment or surface water? If yes, explain.**
Chemicals present on site are limited to the inaccessible soil.

8. **Could chemicals reach receptors via ground water? Can chemicals leach or dissolve to ground water? Are chemicals mobile in ground water? Does ground water discharge into receptor habitats? If yes, explain.** No. While it is possible that chemicals found on the site could leach or dissolve into the ground water, there is no open pathway for ecological receptors due to the depth to ground water and the general lack of sensitive receptors.

9. **Could chemicals reach receptors through runoff or erosion?** Unlikely. The majority of the site is covered by impervious surfaces such as parking lots, buildings, and walkways. The portions of the site not covered by impervious surfaces are protected by landscape plants, mulch, and turf grass.

**Answer the following questions.**

**What is the approximate distance from the contaminated area to the nearest watercourse?**

**0 feet (i.e., contamination has reached a watercourse)**
**1-10 feet**
**11-20 feet**
**21-50 feet**
**51-100 feet**
**101-200 feet**
**> 200 feet**
**> 500 feet**
**> 1000 feet**

**What is the slope of the ground in the contaminated area?**

**0-10%**
**10-30%**
**> 30%**

**What is the approximate amount of ground and canopy vegetative cover in the contaminated area?**

**< 25%**
**25-75%**
**> 75%**

**Is there visible evidence of erosion (e.g., a rill or gully) in or near the contaminated area?**

**Yes**
**No**
**Do not know**

**Do any structures, pavement or natural drainage features direct run-on flow (i.e., surface flows originating upstream or uphill from the area of concern) into the contaminated area?**

**Yes**
**No**
**Do not know**

10. **Could chemicals reach receptors through the dispersion of contaminants in air (e.g., volatilization, vapors, fugitive dust)? If yes, explain.**
    No

11. **Could chemicals reach receptors through migration of non-aqueous phase liquids (NAPLs)? Is a NAPL present at the site that might be migrating towards receptors or habitats? Could NAPL discharge contact receptors or their habitat?** No

## Conclusion

Given the environmental setting/nature of the potential contamination in the inaccessible soils at SLDS, the results of this Ecological Risk Checklist concur with the findings of the 1993 ecological evaluation that the ISOU evaluations should focus on the protection of human health for the following reasons: (1) the SLDS is a heavily urbanized area not suitable for habitation of sensitive and threatened and endangered (T&E) species, (2) it is highly unlikely that potential ecological impacts from the ISOU are greater than those from accessible media, (3) the potential for direct exposures to ISOU media is greater for humans than for terrestrial or aquatic species, and (4) the potential for subsurface migration beneath structures to sensitive terrestrial or aquatic habitats (although none are likely to exist) is unlikely. Also, given that some remediation at the SLDS has since been conducted, potential impacts to ecological resources from the ISOU contaminated media are likely to be even less significant than those determined during the 1993 BRA. Therefore, no comprehensive ecological risk assessment will be performed as part of the ISOU RI.

# FIGURES

# PHOTOGRAPHS

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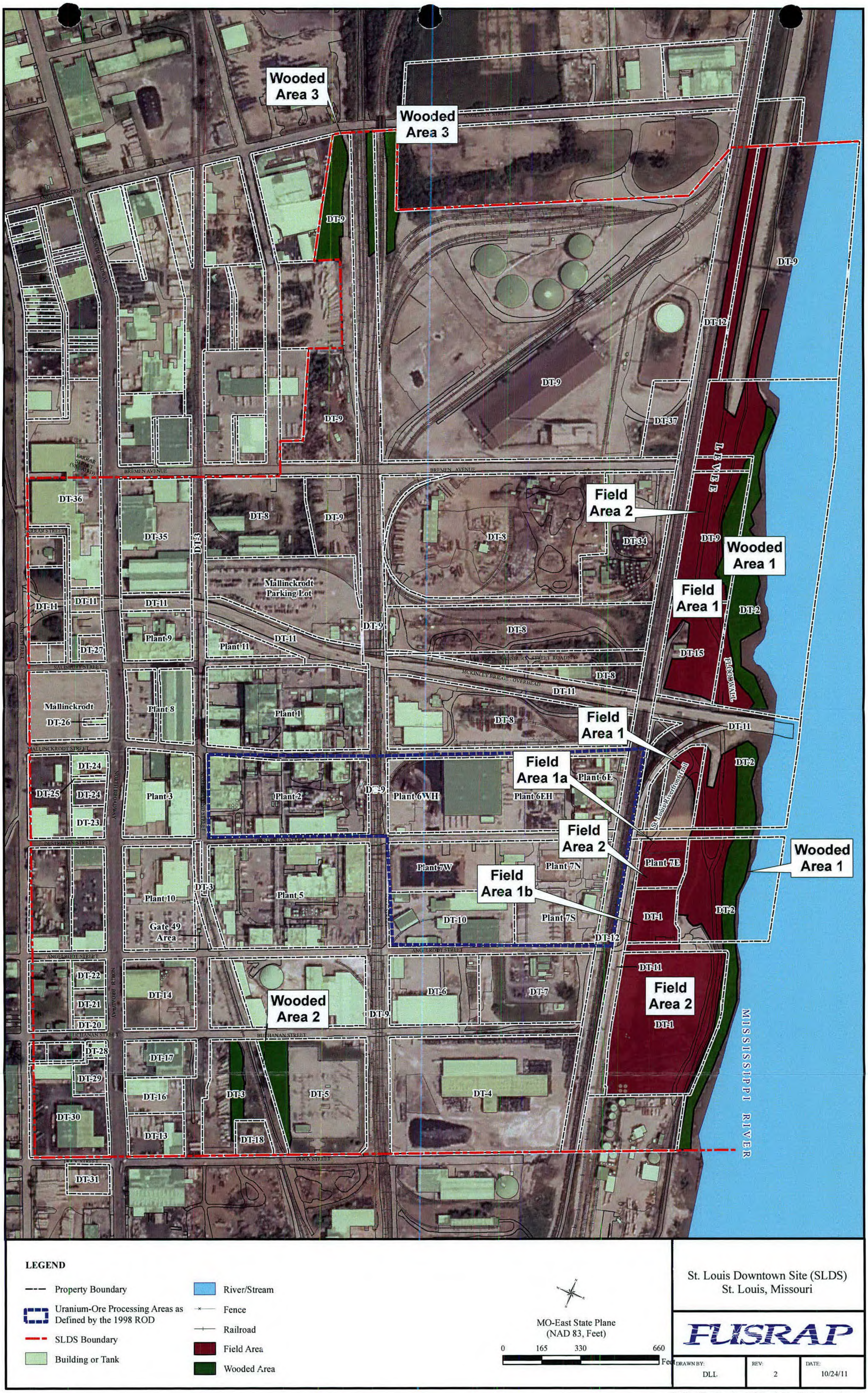
R-1. Topographic Map




St. Louis Downtown Site (SLDS)
St. Louis, Missouri

FUSRAP

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R-2. Ecological Checklist Habitat Areas

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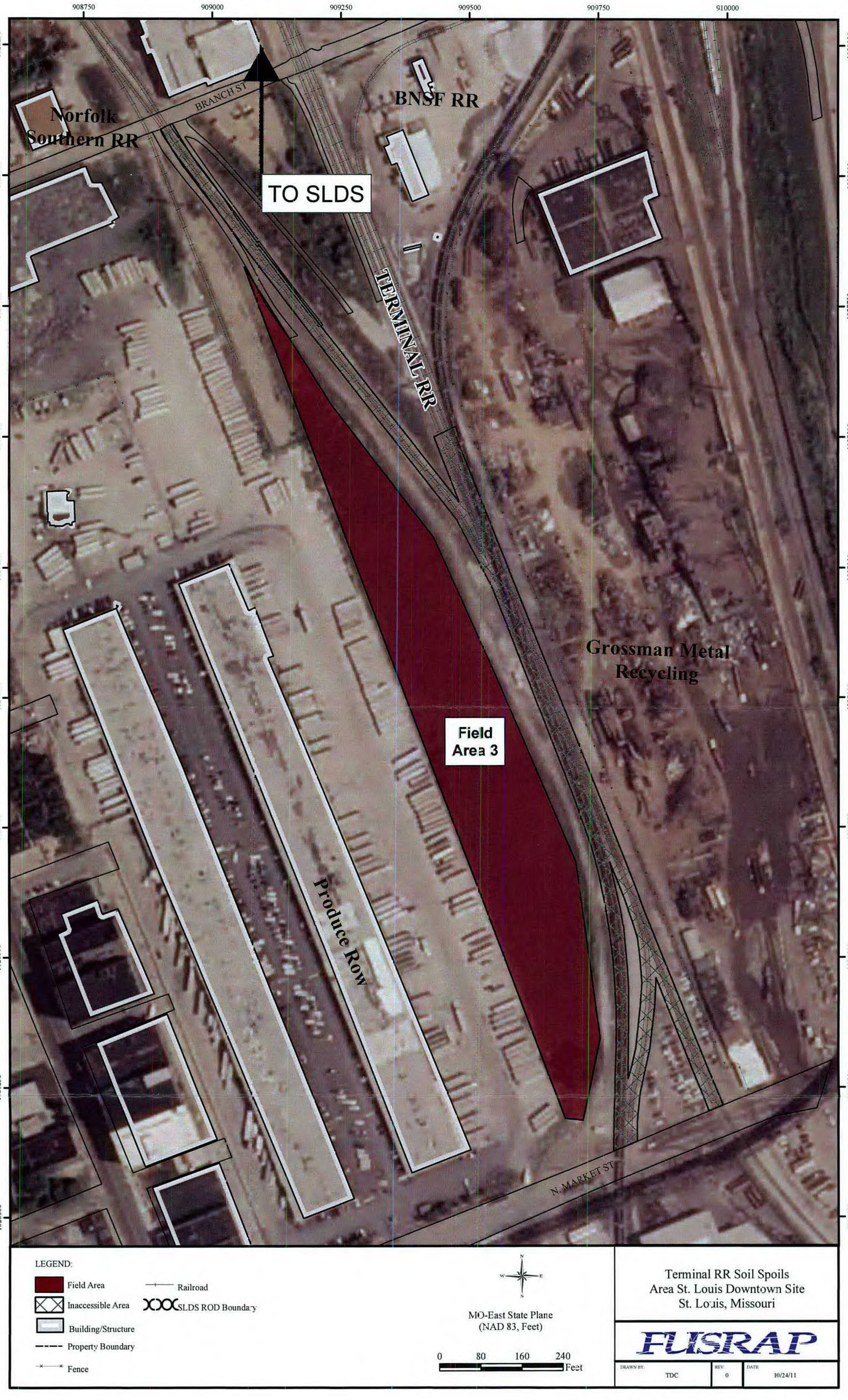


Figure R-3. DT-9 Terminal RR Soil Spoils Area

# Wooded Area 1 (DT-2)

Photo 1. View looking south at the northern edge of the wooded area. McKinley Bridge is visible in the background.


Photo 2. View facing east from the top of the levee at wooded area 1 and field area 1.

Photo 3. View of wooded area facing southeast.

Photo 4. View of understory with the wooded area.

# Wooded Area 2 (DT-5)

Photo 5. View facing southeast at the edge of the Ameren UE substation. Bradford pears are located to the left with the wooded area to the right. Ragweed and lateflowereing thoroughwort are visible in the foreground.

Photo 6. View of wooded area from the railroad tracks. Tree of heaven and lateflowering thoroughwort are the most visible species. Goldenrod and honeysuckle are also present at this location.

Photo 7. View southeast along the southwest edge of Wooded Area 2.

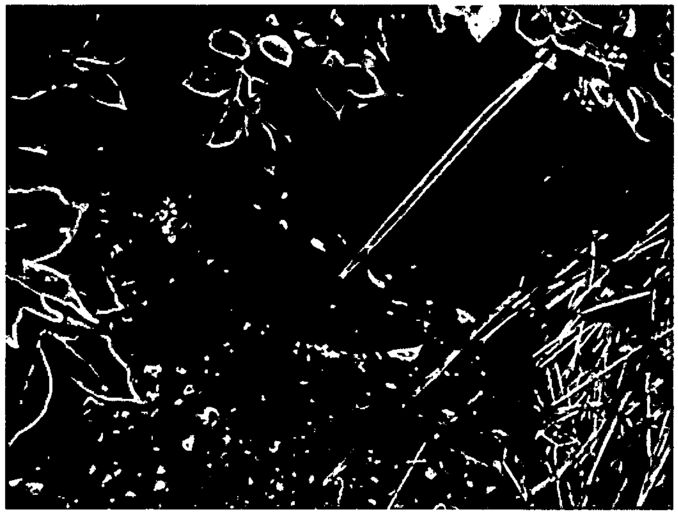

Photo 8. Groundhog den within Wooded Area 2.

# Wooded Area 3 (DT-9)

Photo 9. View from the intersection of Angelica railroad crossing. View is facing southwest at woodland on the southwest edge of the railroad tracks.

Photo 10. View facing south.

Photo 11. View facing southeast with both strips of woods visible at the edge of the photographs.

Photo 12. View of honeysuckle understory.

# Field Area 1a (Plant 7E)


Photo 13. View of DT-1 facing south.


Photo 14. View of DT-1 inside the fenceline facing southeast.


Photo 15. View of DT-1 facing south.


Photo 16. Additional view of DT-1 facing south.

## Field Area 1b (DT-1)

Photo 17. View of DT-1 facing east.

Photo 18. View facing east southeast.

Photo 19. View facing east northeast.

Photo 20. View facing north northeast.

# Field Area 2 (DT-9)

Photo 21. View looking south along the levee. Photograph was taken near the northern boundary of the site. McKinley Bridge is visible in the background.

Photo 22. View facing north at the toe of the levee. Photograph shows Johnson grass to the right with several cottonwoods visible in the background.

Photo 23. View facing north from the top of the levee. Johnson grass, ragweed, wormwood species are visible along the top and toe of the levee.

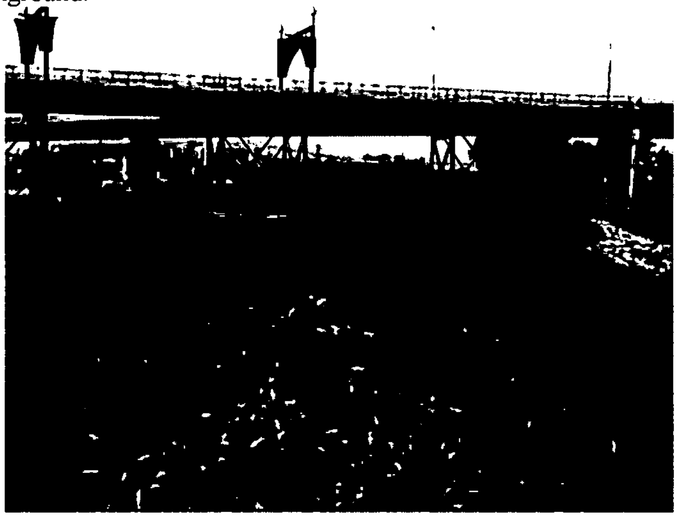

Photo 24. Mowed portion of the levee near McKinley bridge.

## Field Area 3 (Railroad Spoil Area)

Photo 25. View facing southeast of railroad spoil area.

Photo 26. View facing northwest.

Photo 27. View facing southwest into vegetation portion of site. Eastern cottontail rabbit is highlighted within the red circle.

## Mississippi River

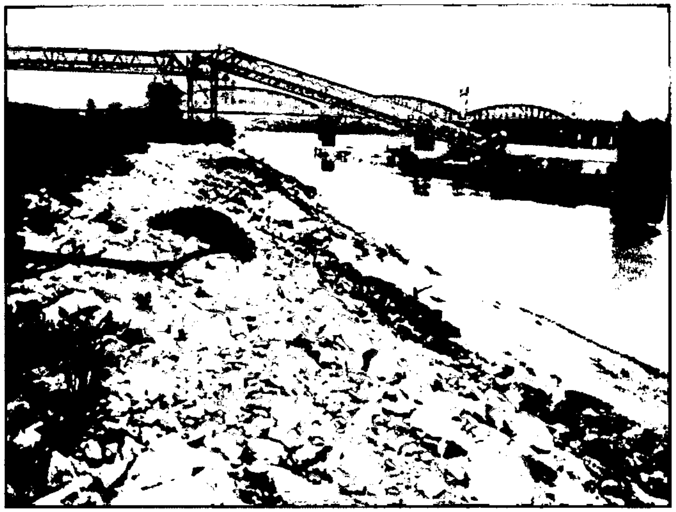

Photo 28. View north along the bank of the river near the northern boundary of SLDS.

Photo 29. View facing south along the riverbank.

Photo 30. View of the riverbank in the vicinity of McKinley bridge.

Photo 31. View facing east across the river.

# Miscellaneous Photographs

Photo 32. View facing southwest along rail line. Gunther Salt (DT-4) is visible to the right. Note the vegetation along the fence line and underneath the elevated walkway.

Photo 33. View facing southwest along Buchanan Street at the fenceline next to DT-4 and at the mowed turfgrass adjacent to the USACE trailers.

Photo 34. View facing north at the Riverfront Trail. This photograph was taken near the north end of SLDS across from DT-9.


Photo 35. Entrance to the Riverfront Trail at the end of Branch Street just south of the SLDS boundary.

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