FINAL

RECORD OF DECISION FOR THE ST. LOUIS DOWNTOWN SITE

ST. LOUIS, MISSOURI

OCTOBER 1998

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

with assistance from
Science Applications International Corporation ESC-FUSRAP
under Contract No. DACA62-94-D-0029

I. DECLARATION FOR THE RECORD OF DECISION

Site Name and Location

St. Louis Downtown Site Accessible Soil/Ground Water Operable Unit
St. Louis Site
St. Louis, Missouri

Statement of Basis and Purpose

This document presents the selected remedial action for the cleanup of wastes related to Manhattan Engineering District/Atomic Energy Commission (MED/AEC) operations in accessible soils and ground water at the St. Louis Downtown Site (SLDS). Accessible soils are soils that are not beneath buildings or other permanent structures. The SLDS is one of a set of properties collectively referred to as the St. Louis site in St. Louis City and County, Missouri. The U.S. Environmental Protection Agency (EPA) has listed portions of the St. Louis site on the National Priorities List (NPL), but the SLDS is not included. The SLDS consists of property owned by Mallinckrodt, Inc. (Mallinckrodt Property), and vicinity properties (VPs). VPs are categorized as perimeter VPs, which are adjacent to the Mallinckrodt Property, as well as the utilities, roads, and railroads, which are located within the Mallinckrodt Property boundaries.

The selected alternative was developed in accordance with the Comprehensive Environmental, Response, Compensation, and Liabilities Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on information available in the Administrative Record for the site.

This Record of Decision (ROD) is published by the U.S. Army Corps of Engineers (USACE) in consultation with the EPA. The Missouri Department of Natural Resources (MDNR) concurs in the selected remedy.

Assessment of the Site

Actual or threatened exposure to MED/AEC-related hazardous substances (primarily radioactivity) at the SLDS, if not addressed by implementing the response action selected in this ROD, may present a current or potential threat to public health, welfare, or the environment.

Description of the Selected Remedy

The selected remedy for this Operable Unit (OU), i.e., Alternative 6 of the Feasibility Study, Selective Excavation and Disposal, is the final remedial action for accessible soils at and ground water beneath the SLDS for MED/AEC-related hazardous substances. Portions of properties were previously cleaned under removal action authorities. Plant 10 (City Block 1201) was cleaned to composite criteria (ARAR based). The Mississippi River levee area was cleaned to risk-based levels based upon recreational use. These cleaned areas do not present risks outside the acceptable risk range and no further remediation is required.

The main components of the selected remedial action include:

- Excavation and off-site disposal of approximately 65,000 cubic meters (85,000 cubic yards) (in-situ) contaminated soil, and

- No remedial action is required for ground water beneath the site. Perimeter monitoring of the ground water in the Mississippi River alluvial aquifer, designated as the hydrostratigraphic B Unit, will be performed and the need for ground water remediation will be evaluated as part of the periodic reviews performed for the site.

Statutory Determinations

The selected remedy is protective of human health and the environment, complies with requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. The selected remedy uses permanent solutions to the maximum extent practicable. Because no "principal threats" were identified for this Operable Unit and because the toxicity of radionuclides cannot be reduced through treatment, this operable unit's remedial action does not satisfy the statutory preference for treatment as a principal element. However, treatment is a conditional part of this remedy. Treatment technologies demonstrated to be cost-effective, may be added as an adjunct to excavation.

Because the selected remedy will result in hazardous substances remaining onsite, a review will be made of the adequacy of the selected remedial action no less often than every five years as required by Section 121(c) of CERCLA.

Russell L. Fuhrman
Major General, USA
Director of Civil Works

3 Aug 98
Date

Dennis Grams, P.E.
Regional Administrator
U.S. Environmental Protection Agency

Aug. 27, 98
Date

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LIST OF ACRONYMS

AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liabilities Act
CFR	Code of Federal Regulations
COC	contaminant of concern
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FFA	Federal Facilities Agreement
FS	Feasibility Study
FUSRAP	Formerly Utilized Sites Remedial Action Program
HI	Hazard Index
MARSSIM	*Multi–Agency Radiation Survey and Site Investigation Manual*
MCL	Maximum contaminant limit
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineer District
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
SMCL	Secondary maximum contaminant level
TCLP	toxicity characteristic leaching procedure
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound
TBC	to be considered

II. DECISION SUMMARY

1 SITE NAME, LOCATION, AND DESCRIPTION

1.1 PHYSICAL SITE LOCATION

The St. Louis Site is a set of properties grouped in two areas in St. Louis City and St. Louis County, Missouri (Figures 1-1 and 1-2). The St. Louis Downtown Site (SLDS) is the subject of this remedial action. The SLDS is located in an industrialized area on the eastern border of St. Louis, 90 m (300 ft) west of the Mississippi River and 18 kilometers (km) [11 miles (mi)] southeast of the Airport Area (Figure 1-3). The SLDS consists of the Mallinckrodt Chemical Works (Mallinckrodt Property), owned by Mallinckrodt, Inc. (Mallinckrodt), and VPs. The Mallinckrodt Property is bordered by a large metal recycling company (McKinley Iron Works) to the north; the Mississippi River, an abandoned food processing plant (PVO Foods), and City of St. Louis property to the east; a large lumber yard (Thomas and Proetz Lumber) to the south; and Broadway Street and small businesses to the west. Additionally, the Norfolk and Western Railroad; the Chicago, Burlington, and Quincy Railroad; and the St. Louis Terminal Railroad Association have active rail lines passing in a north/south direction through the Mallinckrodt Property. An earthen levee between the river and the SLDS protects the area from flood waters. These commercial and city-owned properties are collectively referred to as the SLDS VPs. Perimeter VPs include the City of St. Louis property, PVO Foods, McKinley Ironworks, and Thomas and Proetz Lumber Company. Manufacturing plants, support facilities, and administrative buildings cover a large portion of the site with the rest of the complex covered mostly with asphalt or concrete.

As a result of characterization of the soil, ground water, surface water, sediment, air, and structures associated with the SLDS, radiological contamination attributable to MED/AEC operations at Mallinckrodt was determined to be present in surface and subsurface soils. The principal risk concern is potential exposure to radiological contaminants of concern (COCs) attributable to MED/AEC operations at the site which include the thorium, actinium, and uranium decay series.

1.2 ENVIRONMENTAL SETTING

1.2.1 Land-use and Demography

1.2.1.1 Land-use

Land-use within a 1.6-km (1-mi) radius of the SLDS reflects a mixture of commercial, industrial, and residential uses. The majority of the SLDS is property owned by Mallinckrodt Inc., which has used the property for chemical manufacturing and related operations since 1867. Mallinckrodt currently maintains 24-hr security at the property and limits site access to employees, subcontracting employees, and authorized visitors. The SLDS is enclosed by a well-maintained security fence. Mallinckrodt’s health and safety plans include measures intended to protect

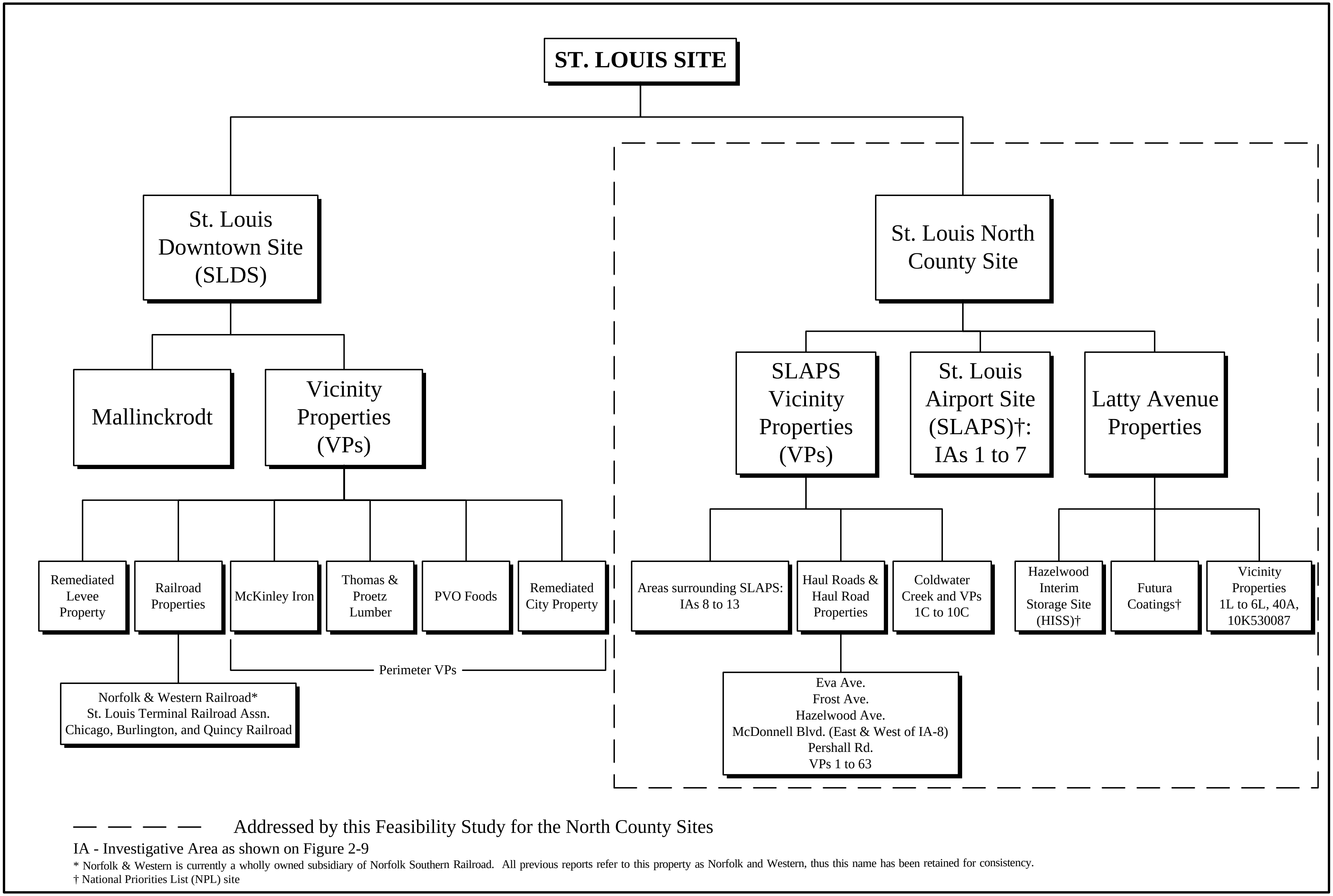
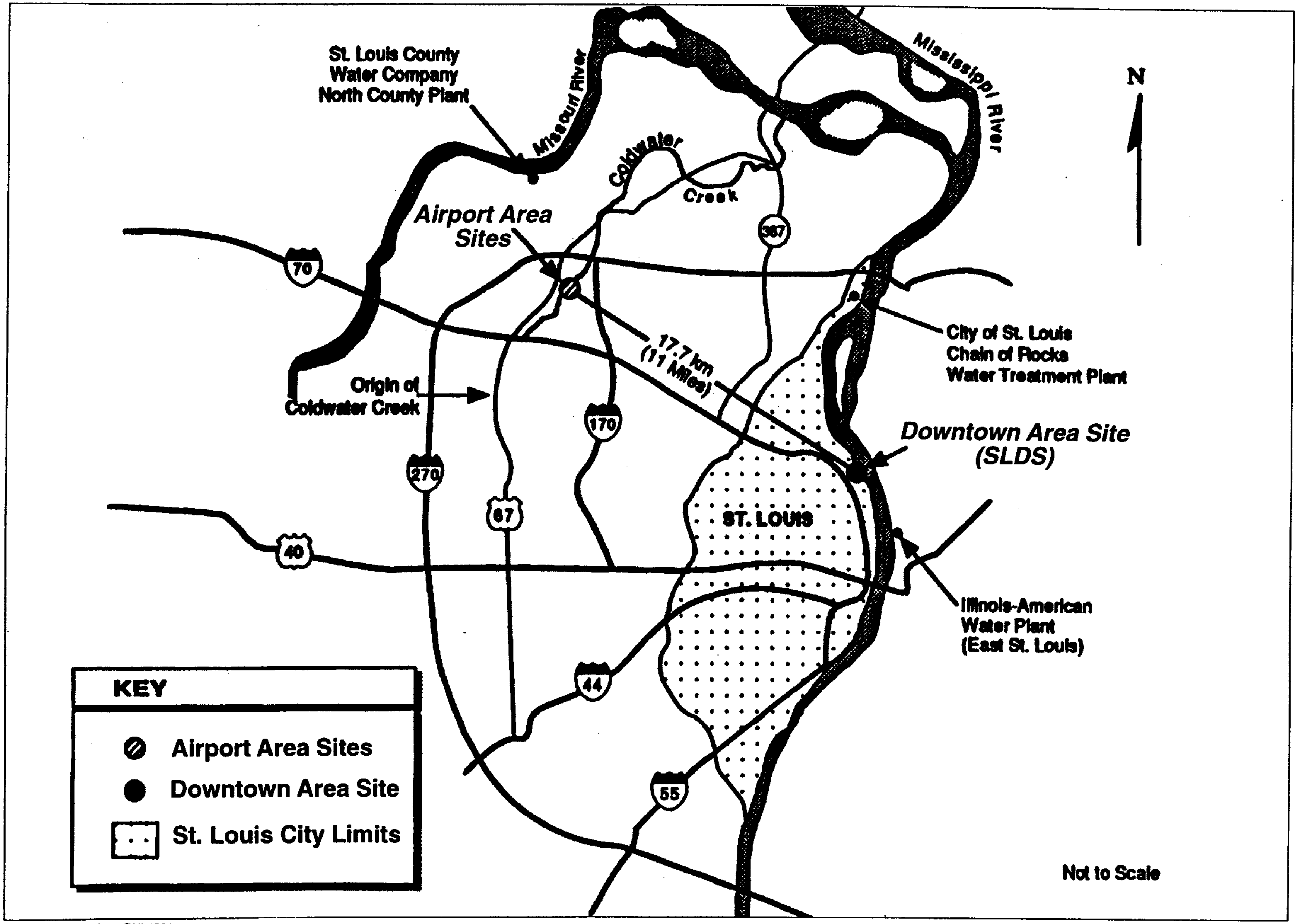


Figure 1-1. Schematic Representation of the FUSRAP St. Louis Site



Source: Modified from BNI 1991

FUS St. Louis 3 01/98

Figure 1-2. Locations of FUSRAP Properties in the St. Louis, Missouri Area

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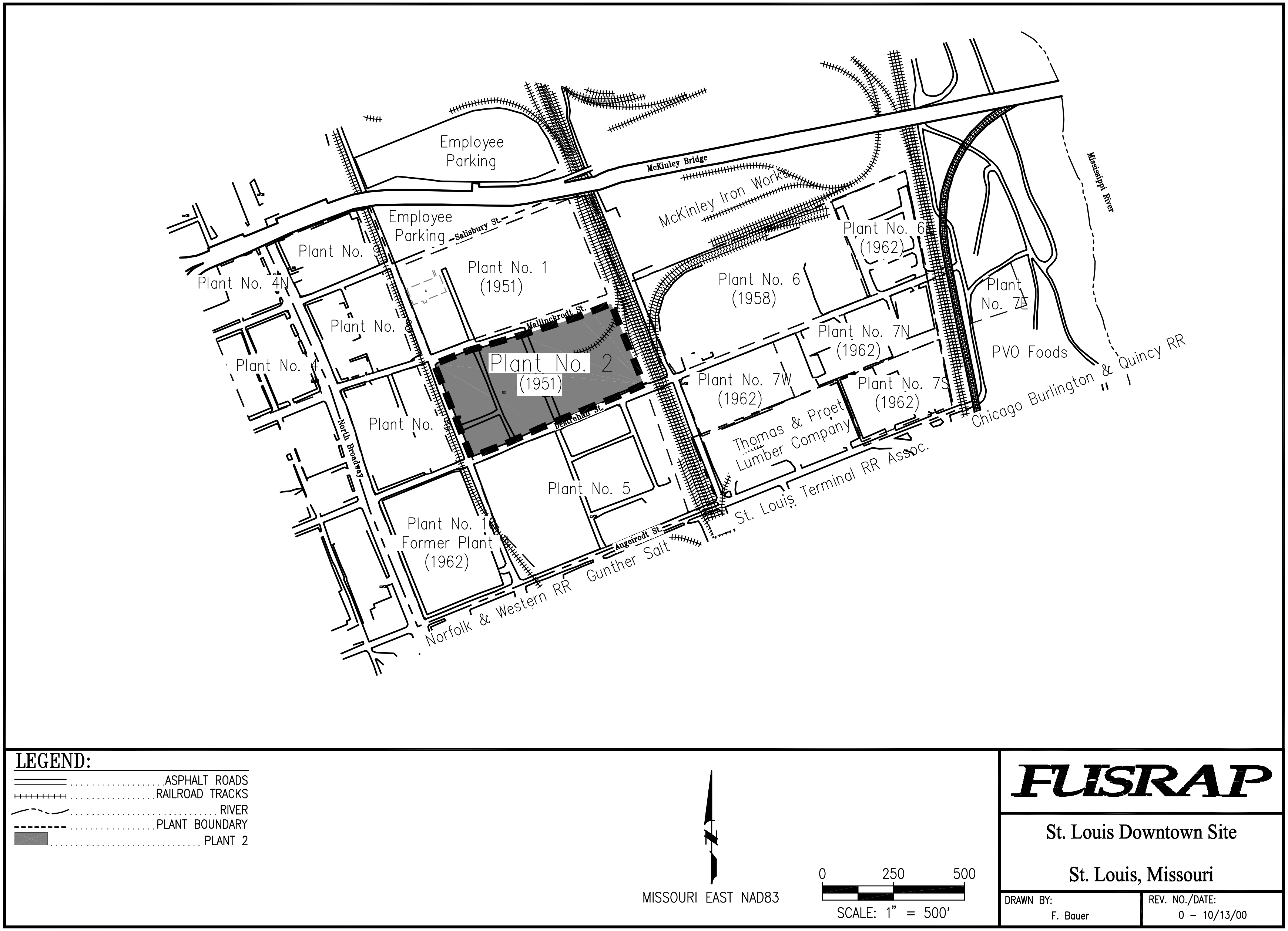

Figure 1-3. Plan View of the St. Louis Downtown Site

employees and visitors from excessive exposure to site contaminants. Zoning regulations prohibit new residences from being established in the area and state regulations require "a well shall be ...constructed ...exclude all known sources of contamination from the well, including sources of contamination from adjacent property" (10 CSR 23-3 010 (1) (A) (4). Two VPs, the McKinley Iron Company and the Thomas and Proetz Lumber Company, are used for commercial or industrial purposes. A third commercial operation, PVO Foods, has closed and the property has been abandoned. Three other VPs are the Chicago, Burlington, and Quincy Railroad; the Norfolk and Western Railroad; and the St. Louis Terminal Railroad Association, which transect the SLDS from north to south. These railroads are actively used as transportation corridors. A VP owned by the City of St. Louis is located between Mallinckrodt and the Mississippi River. With the exception of a recreational bike trail installed in 1997, the City Property is undeveloped. The closest residential dwelling is located on North Broadway, 60 m (200 ft) southwest of the southwestern corner of the SLDS.

The SLDS, as well as most properties east of Broadway and south of Merchants Bridge, has been used as an industrial area for well over a century. The area is currently zoned industrial, which does not allow residential land-use. Some uses allowed within this zone under conditional use permit are acid manufacture, petroleum refining, and stockyards. The long-term plans for this area are to retain the industrial uses, encourage the wholesale produce district, and phase out the remaining, marginal residential uses.

1.2.2 Topography, Drainage, and Surface Water

St. Louis is located in an area of gently rolling uplands which gradually flattens out to the north and east in Illinois. The hilly terrain is cut by several broad river valleys (up to 16 km [10 mi] wide) with steep bluffs. The Illinois and Mississippi Rivers join northwest of the City of St. Louis, to be joined by the Missouri and Meramec Rivers from the west. The Mississippi River at St. Louis has a drainage area of approximately 1.8×10^6 km^2 (700,000 mi^2). The average flow for a 114-year period is 5×10^6 m^3/s [177,000 cubic feet per second (cfs)]. Although flooding has occurred every month of the year, higher flows are usually associated with snow melt and heavy rains in spring.

The water quality of the Mississippi River in the St. Louis area is fair to good and generally meets the water quality standards set by the State of Missouri. Increased levels of polychlorinated biphenyls (PCBs) present downstream from St. Louis suggest that a significant source of PCBs is present in the St. Louis area. No PCBs have been found at the SLDS. The Mississippi, Missouri, and Meramec Rivers supply 97 percent of the 4.5 billion liters (1.2 billion gallons) per year of drinking and industrial water for the St. Louis metropolitan area.

The SLDS is on the western bank of the Mississippi River, 20 km (13 mi) downstream from the confluence of the Mississippi and Missouri Rivers. Runoff from the SLDS flows into the Mississippi River through an underground drainage system. All St. Louis-area municipal water intakes are located upstream of the SLDS except the Illinois-American Water Plant. The Illinois-American Water Plant 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 12 km (8 mi) downstream of the SLDS on the opposite bank of the Mississippi River. The intake is sufficiently far from any potential SLDS release points to preclude the possibility of intake of significant contamination from SLDS.

1.2.3 Geology/Soils

The geologic history of the St. Louis area is characterized by the cyclic deposition of 1,800 m (6,000 ft) of Paleozoic sandstones, shales, limestones, and dolomites. These layers thicken into the Illinois Basin to the east and toward the Ozark Dome to the southwest. They are nearly horizontal, dipping less than 1 degree to the northeast as a result of uplift of the Ozark Dome.

The stratigraphic section of interest for this site consists of the Pennsylvanian and Mississippian bedrock and the overlying Pleistocene and recent nonlithified sediments. The surficial sediments consist of sand, silt, and clay that typically range from less than 1.5 m (5 ft) to more than 30 m (100 ft) thick. These surficial deposits originated from multiple sources: glacial outwash consisting of mixtures of clay, silt, sand, and gravel; silts and clays deposited in glacial lakes; wind-deposited loess; and deposits from the Mississippi and Missouri rivers.

The SLDS stratigraphy (Figure 1-4) is characterized from surface to bedrock by a fill layer present over most of the property with an average thickness of 4 m (13 ft) and nonlithified alluvial deposits of stratified clays, silts, sands, and gravels which are located beneath the fill. Industrial fill has been placed on top of the original floodplain to depths of up to 9m (30 ft) as the area has been developed.

Limestone bedrock of Mississippian age underlies the unconsolidated sediments at a depth ranging from 6 m (19 ft) on the western side of the SLDS to 24 m (80 ft) near the Mississippi River.

1.2.4 Hydrogeology/Ground Water

Ground water at the SLDS is found within three horizons (or hydrostratigraphic units): the upper, nonlithified (soil) unit, referred to as the “A Unit;” the lower, nonlithified unit, referred to as either the Mississippi Alluvial Aquifer or the “B Unit;” and the bedrock (the lithified water-bearing unit), referred to as the “C unit” (Figure 1-4). The Mississippi Alluvial Aquifer is the principal aquifer in the St. Louis area, including the SLDS area. Aquifers in this region also exist in the bedrock formations underlying the alluvial deposits. Ground waters of the St. Louis area are generally of poor quality and do not meet drinking water standards without treatment. Expected future use of ground water at the SLDS is minimal, since the higher quality and large quantity of the Mississippi and Missouri Rivers is readily available.

The A Unit is heterogeneous and the youngest of the three hydrostratigraphic horizons. This young horizon overlies the B Unit on the east and bedrock on the west at the SLDS. The A Unit has the largest range of soil constituents and thus a great spread in hydraulic conductivities spatially. This uppermost unit does not have water levels or flow directly related to the river stage. The base of the A Unit consists of fine-grained deposits behind the Mississippi River’s natural levee. The A Unit also had meandering creeks and swampy low topography prior to the introduction of fill material. In the 1800’s the A Unit’s surface was raised with the least expensive, most readily

Unit Designation	Graphic Column	Approximate Thickness(ft)	Description
Upper Hydrostratigraphic Unit (A)		0-25	**RUBBLE and FILL** Grayish black (N2) to brownish black (5YR2/1). Dry to slightly moist, generally becoming moist at 5-6 ft and saturated at 10-12 ft. Slight cohesion, variable with depth, moisture content and percentage of times present. Consistency of relative density is unrepresentative due to large rubble fragments. Rubble is concrete, brick, glass, and coal slag. Percentage of fines as silt or clay increases with depth from 5 to 30 percent. Some weakly cemented aggregations of soil particles. Adhesion of fines to rubble increases with depth and higher moisture content. Degree of compaction is slight to moderate with frequent large voids
		0-10	**Silty CLAY (CH)** 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. Abundant dark, decomposed organics. Variable percentages of silt and clay composition.
		0-5	**CLAY (CL)** 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. Slight to moderate plasticity.
		0-2.5	**Interbedded CLAY, silty CLAY, SILT and Sandy SILT (CL, ML, SM)** 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. Some very fine-grained, rounded silica sand as stringers. Silt in dark matic, biotite flakes. Some decomposed organics.
Lower Hydrostratigraphic Unit (B)		0-10	**Sandy SILT (ML)** 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. Sand is well sorted, very fine and fine-grained rounded quartz particles.
		0-50	**Silty SAND and SAND (SM, SP, SW)** Olive gray (5Y4/1). Saturated, slight cohesion, becoming noncohesive with decrease of silt particles with depth. Dense, moderate compaction. Moderate to well-graded, mostly fine- and medium-grained, with some fine- and coarse-grained particles. Mostly rounded with coarse grains slightly subrounded. Gradual gradation from upper unit, silty sand has abundant dark matic/biotite flakes. Sand is well-graded, fine gravel to fine sand. Mostly medium-grained, with some fine-grained and few coarse-grained and fine gravel.
Bedrock Unit (C)		Total thickness not penetrated during drilling	**LIMESTONE** Light olive gray (5Y4/1) with interbedded chart modules. Generally hard to very hard; difficult to scratch with knife. Slightly weathered, moderately fresh with little to no discoloration or staining. Top 5 ft is moderately fractured, with 99 percent 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 1992.
NOTE: THE CODES IN PARENTHESES FOLLOWING LITHOLOGIES ARE THE UNIFIED SOIL CLASSIFICATION SYSTEM CODES.

NOT TO SCALE

FUSRAP

SLDS ROD
St. Louis, Missouri

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Figure 1-4. Generalized Stratigraphic Column for the SLDS

available fill materials: rubble and wood and coal combustion wastes, e.g., coal slag and cinders. The combustion products used for fill had inherently high metal concentrations. The infiltration and throughput of water in the A Unit is relatively minor, since the ground surface has large areas of buildings, road surfacing, and channeled surface water flow. This shallow unit is not a productive source of water due to poor yield and its multiple chemical constituents. The A Unit is not an aquifer and is not considered a potential source of drinking water because it has insufficient yield, poor natural water quality, and susceptibility to surface water contaminants of the industrial setting. The long-term industrial filling of the site and the present industrial setting also are factors in the consideration that the A Unit, the most shallow hydrostratigraphic horizon, is not a drinking water resource.

The B Unit thins westwardly on the rock surface until it becomes absent beneath the SLDS, being truncated by the rising bedrock and the A Unit (Figure 1-5). The B Unit may attain a thickness of 20 m (70 ft) to the east at the river. The ancestral Mississippi River deposited the B Unit's sediments after the river's greatest erosion of the bedrock floor. Unit B is a horizon of fining-upward, interfingered and crosscut sands and gravels with direct hydraulic connection to the Mississippi. The granular nature and association with the river allows the B Unit to have unique chemical and hydraulic character. The B Unit has high dissolved solids and metal concentrations (iron and manganese above their Secondary Maximum Contaminant Levels, SMCLs). The dissolved solids and metal content are naturally occurring. The aquifer's pressure and flow direction react to changing river stages. The source of the B Unit's ground water recharge at low river stages is upgradient flow from the bedrock unit and minor downward infiltration from the A Unit. Water at high river stages, or under heavy pumping loads, is predominantly from the Mississippi. Recharge from the B Unit aquifer is available at high volumetric rates. Extracted water from the B Unit would require treatment to reduce the natural total dissolved solid and metal content. The use of the B Unit for a drinking water resource is highly unlikely for several reasons: the industrial setting of the SLDS, the site's proximity to both the Mississippi and the city's drinking water supply, and the poor natural water quality of the B Unit. However, the B Unit does qualify as a potential source of drinking water under the "Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy" (Final Draft, December, 1986).

The C unit surface slopes from the western uplands to the river. The limestone bedrock has nearly horizontal bedding, which slopes only a few degrees to the east. Solution channels and fractures dominate the water routes through the bedrock. Uplands recharge of the C unit flows downgradient to the river valley providing recharge to the B Unit, the Mississippi Alluvial Aquifer. The C unit would be an unlikely water supply source, as it is deeper and a less productive hydrostratigraphic unit.

1.2.5 Ecology

The St. Louis Downtown Site is located in the Oak-Hickory-Bluestem Parkland section of the Prairie Parkland Province. Topography is gently rolling with low bluffs north of the Missouri. Presettlement vegetation is characterized by deciduous woodlands intermixed with open prairie. Today, because of extensive industrialization, little presettlement vegetation exists in the area including the St. Louis Downtown Site.

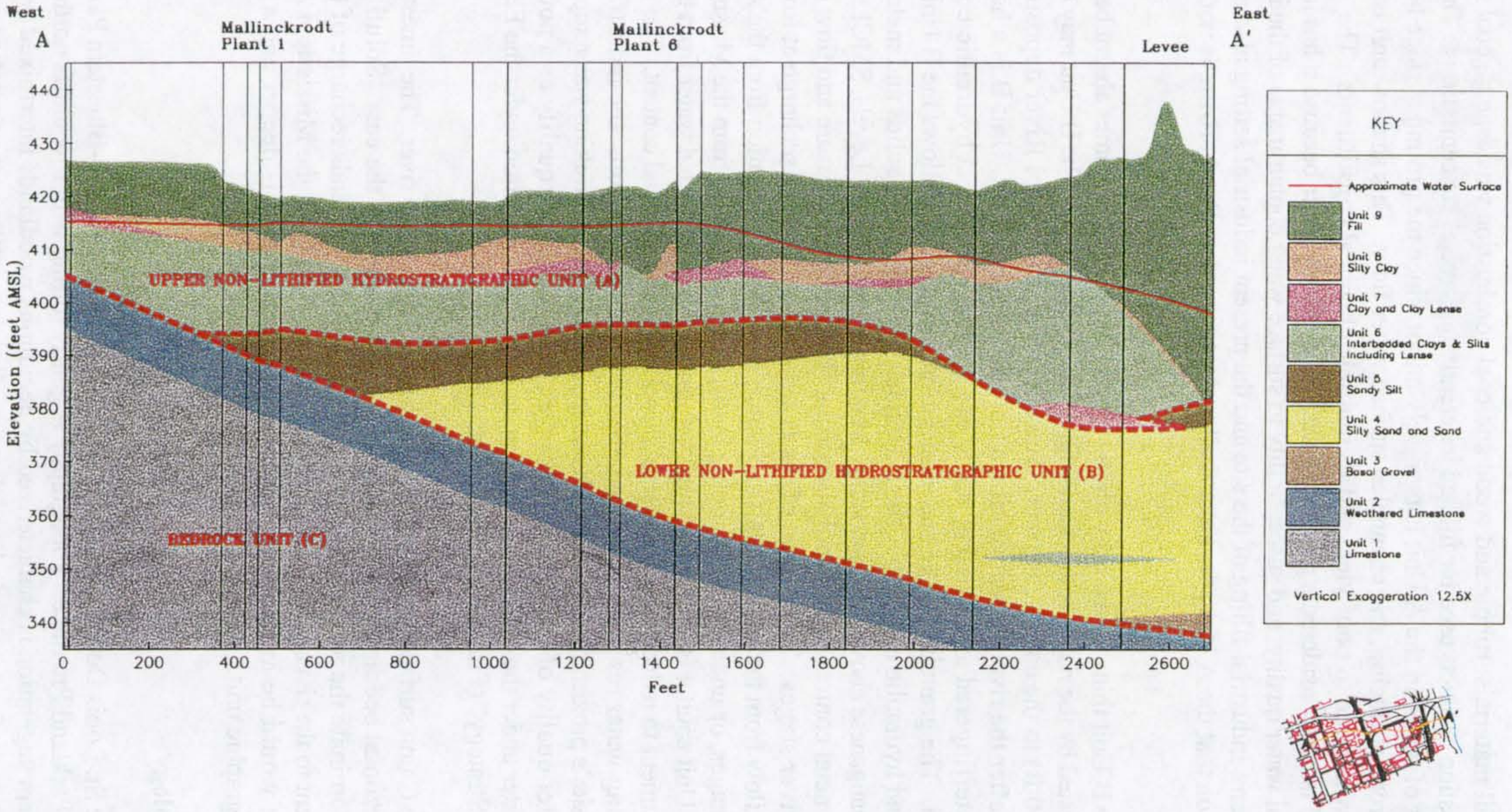

Figure 1-5. Hydrostratigraphic Units of the SLDS area

The SLDS is completely developed; therefore, almost no biological resources exist on or near the SLDS. This is related to several decades of highly urbanized land uses surrounding the site. The only animals observed at the SLDS during the site survey were insects (e.g., ants) and swifts (Chaetura pelagica), red-winged blackbirds (Agelaius tricolor), and pigeons (Columba livia) flying through the area. Small mammals, particularly house mice (Mus musculus) and rats (Ratus sp.) have habitat in the area.

1.2.6 Archaeological and Historical Sites

Two sites listed in the March 1992 edition of the National Register of Historic Places for the State of Missouri exist within a 1.6-km (1-mi) radius of the SLDS. The first site is the Bissell Street Water Tower, located approximately 1.3 km (0.8 mi) northeast of the SLDS. The second is the Murphy-Blair Historic District located 0.8 km (0.5 mi) from the SLDS.

SLDS does not contain any historic buildings. Available data indicate no archaeological sites in the area. Consultation with the State Historic Preservation Officer has been completed. However, no archaeological survey of the property itself has been conducted. The site is covered by a fill layer averaging 4 m (13 ft) which overlies alluvial deposits extending to 24.0 m (80 ft). The degree of disturbance beneath the fill layer is not presently known. The property is approximately 0.4 km (0.25 mi) from the former location of an American Indian mound group, the St. Louis Mounds.

2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

Mallinckrodt Inc., since 1867 at this facility, has used, blended, and/or manufactured chemicals, including organics (e.g., 1,2-dichloropropane, dichloromethane, phenol, zinc phenolsulfonate, toluene, hexane, dimethylaniline, chloroform, alcohols, propanediols, nitrobenzene, nitrophenols, xylenes, trichloroethene, hexachlorobutadiene, oxydianiline tars, stearates, biphenyls, acetonitrile), and inorganics (e.g., aluminum chloride, hydroxide salts, zinc, sulfuric acid, nitric acid, hydrochloric acid, chromium, sodium iodide, magnesium salts, palladium, bismuth oxychloride). A number of chemicals and compounds that have been associated with non-MED/AEC operations have been detected in soil and ground water. A levee/floodwall located to the east of the SLDS protects the area from flood waters.

Mallinckrodt Chemical Works, from 1942 until 1957, was contracted by MED and AEC to process uranium ore for the production of uranium metal. Residuals of the process, including spent pitchblende ore, process chemicals, and radium, thorium, and uranium, were inadvertently released from the Mallinckrodt Property and into the environment through handling and disposal practices. Residuals from the uranium process had elevated levels of radioactive radium, thorium, and uranium. From 1942 to 1945, Plants 1, 2, and 4 (now Plant 10) (Figure 1-3) were involved in the development of uranium-processing techniques, uranium compounds and metal production, and uranium metal recovery from residues and scrap. Uranium-bearing process residues from these operations were stored at the SLAPS and the Latty Avenue Properties from 1946 to 1966. Relocation and storage of these processed wastes at SLAPS and the Latty Avenue Properties resulted in the subsequent contamination of the SLAPS VPs. Mallinckrodt decontaminated Plants 1 and 2 from 1948 through 1950 to meet the AEC criteria then in effect, and the AEC released these plants for use without radiological restrictions in 1951.

Plant 6 produced uranium dioxide from pitchblende ore starting in 1946. During 1950 and 1951, Plant 10 was modified and used as a metallurgical pilot plant for processing uranium metal (until it was closed in 1956) and operations began at Plants 6E, 7, 7E, 7N, and 7S. AEC operations in Plant 6E ended in 1957. AEC managed decontamination efforts (removal of radiologically contaminated buildings, equipment, and soil disposed offsite) in Plants 10, 7, and 6E to meet AEC criteria in effect at that time and returned the plants to Mallinckrodt in 1962 for use without radiological restrictions. Since 1962, some buildings have been razed, and new buildings have been constructed at Plants 10 and 6. Except for Building 25, which will be addressed under a separate CERCLA action, the MED/AEC related buildings have recently been razed, making previously inaccessible contaminated soils available for cleanup.

Process, storm, and sanitary effluent from the SLDS was collected in a combined sewer system for discharge directly to the Mississippi River through a municipal outfall, before the Bissell Point Sewage Treatment Plant went on line in December 1970,. The Bissell Point Sewage Treatment Plant is approximately 1 mile north of the SLDS. After the Bissell Point Sewage Treatment Plant went on line, dry weather sewer flow was collected for treatment prior to release to the river. Mallinckrodt, Inc.'s discharge permit states that discharge of the wastewater shall not be at a rate that would cause the influent at Bissell Point to exceed the 1 Curie per year limit. In times of heavy stormwater flow, when the capacity of the interceptor tunnel under the SLDS is exceeded, excess flow in the municipal sewer is discharged directly into the river.

A radiological survey conducted in 1977 at the SLDS found that alpha and beta-gamma contamination levels exceeded guidelines for release of the property for use without radiological restrictions (ORNL 1981). Elevated gamma radiation levels were measured at some outdoor locations and in some of the buildings formerly used to process uranium ore. Radium (Ra)-226 and uranium (U)-238 activities were found significantly above background in subsurface soil. Additionally, radon and radon daughter activities in two buildings exceeded guidelines for nonoccupational radiation exposure. In response to this survey, it was determined that further investigation was necessary to characterize the nature and extent of contamination, and possible remedial actions to mitigate threats to human health and the environment.

Four interim actions have been performed at SLDS. A summary of these actions is provided in Table 2-1. Actions taken at the site will be conducted under the Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was executed by the U.S. Department of Energy (DOE) to identify and remediate or otherwise control sites where residual radioactivity remains from activities conducted while under contract to MED and AEC during the early years of the nation's atomic energy program or from commercial operations that Congress directed DOE to remediate and that DOE added to the FUSRAP sites. On 13 October 1997, the U.S. Congress transferred responsibility for FUSRAP from the U.S. Department of Energy (DOE) to the USACE through the 1998 Energy and Water Development Appropriations Act. In June 1990, EPA Region VII, and DOE entered into a CERCLA Section 120 Federal Facilities Agreement (FFA). In the FFA, DOE agreed to conduct response actions for 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.

- Other chemical or radiological wastes that have been mixed or commingled with wastes resulting from or associated with MED/AEC uranium manufacturing or processing activities conducted at the SLDS.

The ROD addresses contamination related to MED/AEC activities in accessible soils and ground water. SLDS Buildings 101 and 25 and St. Louis Site's currently inaccessible soils related to MED/AEC activities will be remediated under a future CERCLA action.

In addition, there are two other major environmental contaminant abatement efforts underway at the Mallinckrodt Property. Mallinckrodt, Inc. is pursuing a RCRA Part B permit for their entire facility and is also attempting to terminate their NRC license for the Columbium/Tantalum process conducted in the Plant 5 area. Columbite is the mineral name for $(Fe, Mn)Nb_2O_6$. Tantalite is the mineral name for $(Fe, Mn)Ta_2O_6$.

The USACE will continue to cooperate with the EPA, the State of Missouri and Mallinckrodt, Inc. to ensure that response actions are coordinated so that all site threats are addressed.

Table 2-1. Interim Actions at SLDS Since April 1994

Property	Activities	Volumes Remediated*	Authorizing Document
50 Series Buildings (Bldgs. 50, 51, 51A, 52, and 52A)	Decontamination, demolition, and crushing	1,000 yd^3 shipped off-site; 1,000 yd^3 of crushate stockpiled in a fenced area on Mallinckrodt Inc. property	DOE/OR/23701-02.2
Plant 6 and 7 Buildings (Bldgs. 100, 116, 116B, 117, 700, 704, 705, 706, 707, and 708)	Asbestos abatement, decontamination, demolition to floor elevation grade, crushing	2,673 yd^3 shipped off-site; 7,000 yd^3 of crushate stockpiled on the Mallinckrodt Inc. property, Lot 7E	DOE/OR/23701-02.2
Plant 10 area subsurface soil	Excavation	15,043 yd^3 shipped off-site	DOE/OR/23701-02.2
City Property (Riverfront Trail area)	Excavation	750 yd^3 shipped off-site	DOE/OR/23701-02.2

* These are the volumes shipped. They are greater than the in situ impacted volumes because they include any extra soil to assure removal and the bulking (volume increase) that results from excavation.

Source: DOE 1991. *Engineering Evaluation/Cost Analysis for Decontamination at the St. Louis Downtown Site*, St.Louis, MO, DOE/OR/23701-02.2, May.

3 HIGHLIGHTS OF COMMUNITY PARTICIPATION

Public input has been encouraged by both DOE and the USACE to ensure that the remedy selected for the SLDS meets the needs of the local community in addition to providing an effective solution to the problem.

The Administrative Record, which contains the documentation used to select the response action, is available at the following locations:

Government Information Section
St. Louis Public Library – Central Library
1301 Olive Street
St. Louis, MO 63101

USACE Public Information Center
9170 Latty Avenue
Hazelwood, MO 63134

DOE published a Notice of Intent in the Federal Register on January 9, 1992, to present pertinent background on the scope and content of the St. Louis site RI/FS. The comments, concerns, and written statements from a January 28, 1992 public scoping meeting held at Berkeley Senior High School, Berkeley, Missouri, were published in a Responsiveness Summary and made part of the St. Louis work plan for the RI/FS. In addition, the relevant comments from a December 6, 1990 scoping meeting on the programmatic environmental impact statement were also included in the work plan.

A copy of the Administrative Record File for actions at the SLDS has been maintained by the USACE and DOE at the Public Information Center and the St. Louis City Public Library and is updated quarterly. The community relations program interacts with the public through news releases, public meetings, availability sessions, site tours, public workshops, meetings with local officials and interest groups, and receiving and responding to public comments through correspondence and the information center. The documents describing the results of the integrated process for the St. Louis site have been made available to the public for review and comment at the information repositories noted above. The following documents were issued by USACE and DOE:

- The *Remedial Investigation for the St. Louis Site* (DOE 1994) and the *Remedial Investigation Addendum for the St. Louis Site* (DOE 1995) characterizes the nature and extent of contamination at the site.

- The *Baseline Risk Assessment for the Exposure to Contaminants at the St. Louis Site* (DOE 1993) evaluates the potential risk to human health and the environment from contaminants associated with the site in the absence of any remedial action.

- The *Feasibility Study for the St. Louis Downtown Site* (USACE 1998a) identifies, develops, and evaluates remedial action alternatives for the site based on the nature and extent of contamination documented in the RI.

- The *Proposed Plan for the St. Louis Downtown Site* (USACE 1998b) summarizes background information on the St. Louis site, describes the alternatives considered to clean up the site, presents the rationale for selection of the preferred remedy, and solicits public comment.

From September 1994 through December 1996, a task force known as the St. Louis Site Remediation Task Force studied all aspects of the St. Louis FUSRAP site and formally transmitted the results of their deliberations to the U.S. Department of Energy in the *St. Louis Site Remediation Task Force Report* (September 1996). Specific areas of focus included: 1) identification of alternative disposal sites, 2) health risks/cleanup standards, 3) development of local priorities with respect to cleanup of the site, 4) identification of remedial action alternatives, 5) a screening of technologies that may be applied at the site, and the 6) development of a communications and public awareness plan.

The task force was composed of members appointed by the city and county of St. Louis, adjacent communities, EPA, MDNR, concerned citizens, public utility and local business representatives, representatives of congressmen, and representatives of local environmental groups.

In their summary report, the following statement was provided in Section 4, titled Conclusions and Recommendations. "Further, the Task Force requests that remediation at the St. Louis Downtown site and the City Levee continue or begin with 'site specific' standards for industrial or recreational use, respectively."

The FS and Proposed Plan were released for public comment on April 8, 1998. The public was notified of the public comment period for the Proposed Plan through public mailings, notices in the regional metropolitan and rural newspapers, announcements on local radio stations, and notices delivered to residences in the nearby neighborhood.

The 30-day public comment period began on April 8, 1998. A public meeting was held on April 21, 1998 to provide information about the remedial alternatives and the opportunity to submit comments on the Proposed Plan. A Responsiveness Summary was prepared to address comments received during the public comment period. In general, public comments on the Proposed Plan rejected the USACE preferred alternative (Alternative 4) as too restrictive for property owners; a strong preference for Alternative 6 was expressed by the community. Based on community input and reevaluation of CERCLA cost and risk criteria, the USACE selected Alternative 6 for implementation at the site. The Responsiveness Summary is provided in Appendix A of this ROD.

4 SCOPE AND ROLE OF OPERABLE UNIT

This operable unit is the final remedial action for the accessible soil and ground water contaminated as the result of MED/AEC uranium manufacturing and processing activities at the St. Louis Downtown Site (SLDS). The subsequent response action includes remediation of the two remaining MED/AEC related buildings (buildings 25 and 101) and soil which is currently inaccessible because of the presence of the two buildings, active rail lines, roadways, and the levee. Previously cleaned up properties addressed under removal authority are described in Table 2-1 and include Plant 10 (City Block 1201) and the land east of the levee (DOE 1996, 1997). Remediation of these portions of the site is fully protective and thus they will not require further remediation.

Characterization activities at the SLDS have determined that contamination related to MED/AEC activities is present in the soils of Mallinckrodt, Inc. and VPs at levels that require remedial action. Much of the contamination detected resulted from MED/AEC activities while some of the contamination is the result of other industrial processes associated with Mallinckrodt operations and other nearby industries. Still other contaminants have leached from the coal slag and cinders used as fill in the area. As agreed to under the FFA, hazardous substances resulting from releases on the site during the Mallinckrodt operations for the MED/AEC are the subject of this response action. Contaminants resulting from other actions, or preexisting contaminants at the site are being addressed through actions being carried out by other authorities. This includes both radioactive and hazardous substances which are the responsibility of other parties. The other actions being carried out include termination of a Mallinckrodt NRC license for plant 5 and a RCRA action for the entire Mallinckrodt site. EPA, NRC, the State of Missouri and Mallinckrodt, Inc. are working together to assure that all remaining potential hazards at the site are addressed.

Inaccessible soils that contain MED/AEC contamination and associated buildings and structures are excluded from the scope of this ROD because they do not present a significant threat in their current configuration and because activities critical to the continued operation of the Mallinckrodt facility prevent excavation beneath the encumbrances (ie, roads, railroads, buildings 25 and 101, etc.). Contamination present within building 25 also does not present an excessive risk under its current configuration.

5 SUMMARY OF SITE CHARACTERISTICS

A remedial investigation (RI) (DOE, 1994) was conducted in accordance with CERCLA to determine the nature and extent of contamination at SLDS relevant to this operable unit. Analytical results for radiological and chemical characterization surveys are summarized in the RI report (DOE 1994) and the RI Addendum (DOE 1995). Analyses performed during characterization included thorium (Th)-230, Th-232, radium (Ra)-226, uranium (U)-238, volatile organic compounds (VOCs), base neutral and acid extractable compounds, metals, Resource Conservation and Recovery Act (RCRA)-hazardous waste characteristics, pH, specific conductance, total organic halogens and total organic compounds. Characterization activities were performed at SLDS for soil, air, and ground water. In addition, above ground structures associated with MED/AEC processes were surveyed for fixed and transferable radiological contamination. The results of this investigation for the SLDS are summarized here.

Soil characterization results indicated that the areas associated with MED/AEC activities were principally contaminated with radionuclides. Metals and VOCs were also detected in those areas and across the site, but generally occur in limited pockets. The radiological contaminants associated with MED/AEC activities are readily identifiable because of the distinct suite of radionuclides used in the MED/AEC processes and the location where these contaminants were found. However, the source of the detected non-radionuclide contaminants is not as clear. The potential for non-MED/AEC process-related organic and inorganic releases from the Mallinckrodt Inc. facility and surrounding businesses is substantial given the nature and duration of industrial activities in the area. In addition, the non-MED/AEC columbium–tantalum processing activities and the coal combustion products used as fill in the area may have contributed radioactive contaminants as well as metals and polycyclic aromatic hydrocarbons (PAHs). There is no indication of use or generation of PAHs in MED/AEC processes or operations.

Radionuclide Distribution in Soil

The principal radioisotopes associated with the MED/AEC process at the SLDS are Ra-226, Ra-228, Th-230, Th-232, uranium (including U-238, U-235, and U-234) , and their respective radioactive decay products. Analytical results for radiological surveys at the VPs indicate that the primary radionuclide in soil is Th-230. Figures 5-1, 5-2 and 5-3 show the extent of Ra, Th, and U contamination associated with MED/AEC processes at the SLDS. Figures 5-4 , 5-5 and 5-6 illustrate the vertical profile of contaminants based on projections of the boring data. Most of the contamination is distributed near the surface, but does extend to significant depth (23 ft) at Plant 2. Also, inaccessible soils are found at 13 ft under the levee on property owned by City of St. Louis.

Distribution of Metals in Soil

Metals were found in radiologically contaminated soil, however for arsenic, the detection limit for the data collected during the RI exceeds the mean value for background samples collected in a subsequent investigation (SAIC 1998). All the sources of elevated metal concentrations are not defined. Geologic logging confirming anecdotal evidence indicates a probable source of elevated metal concentrations in soil is the coal combustion products used as fill throughout the property

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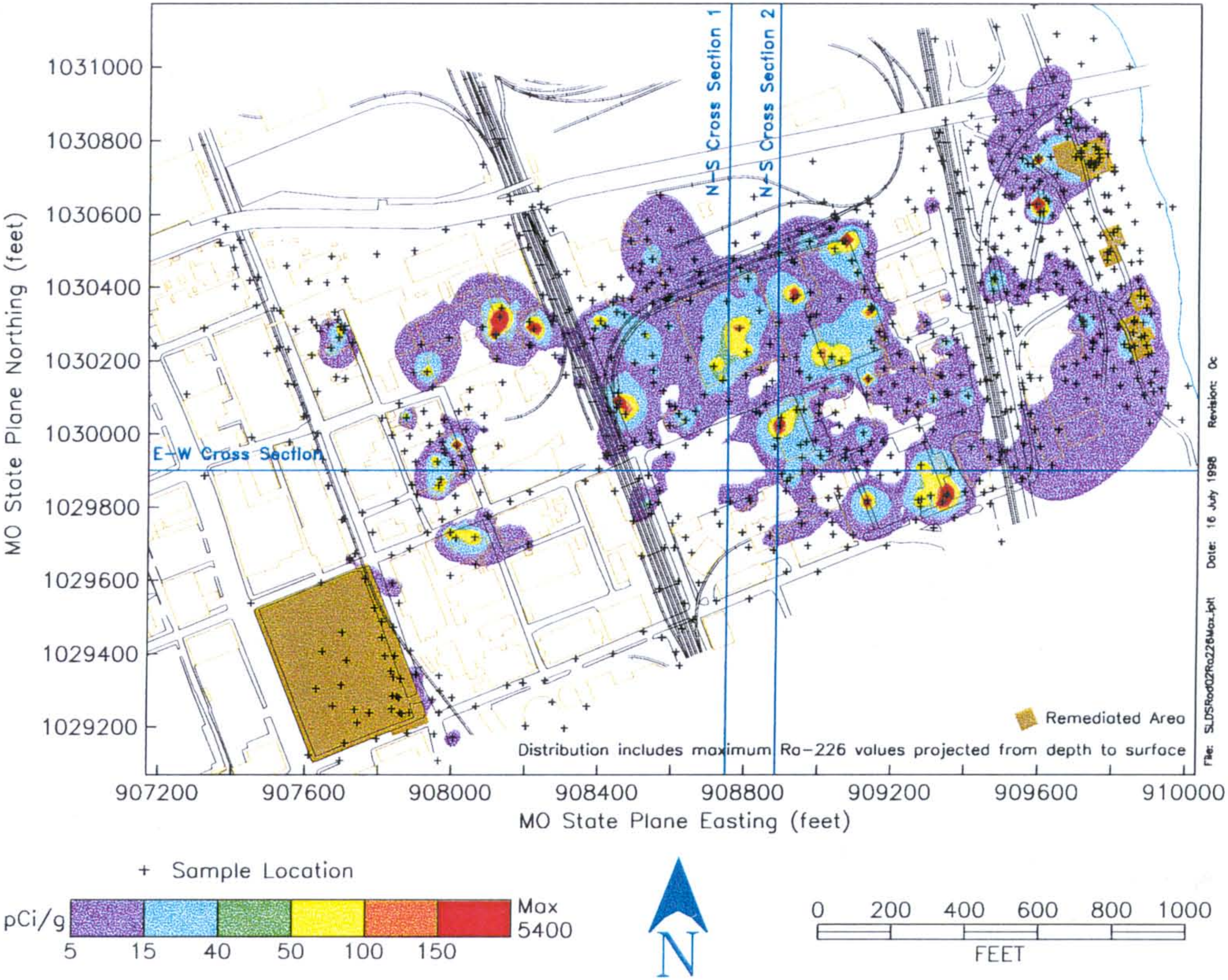

Figure 5-1. Extent of Ra-226 Contamination at SLDS

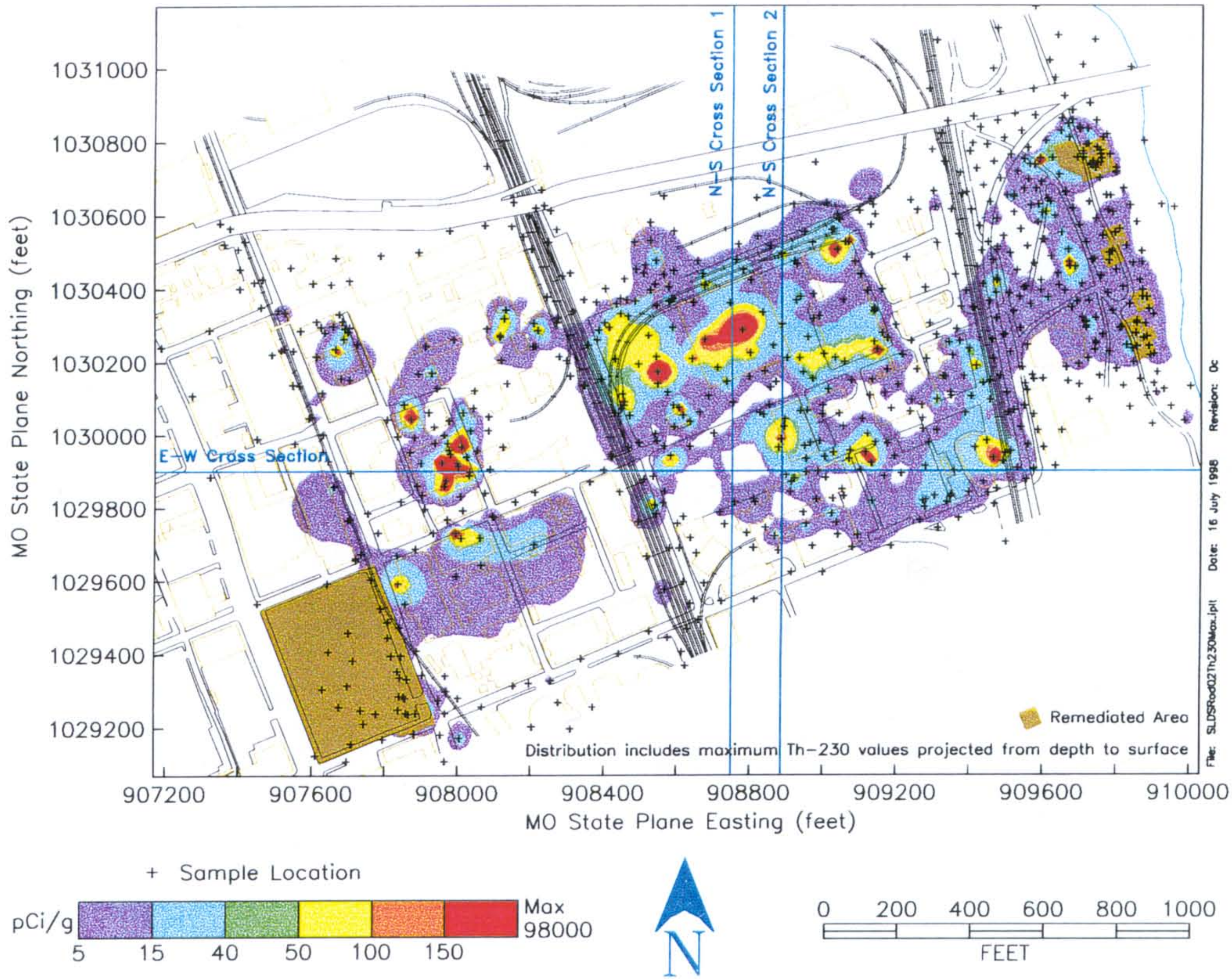

Figure 5-2. Extent of Th-230 Contamination at SLDS

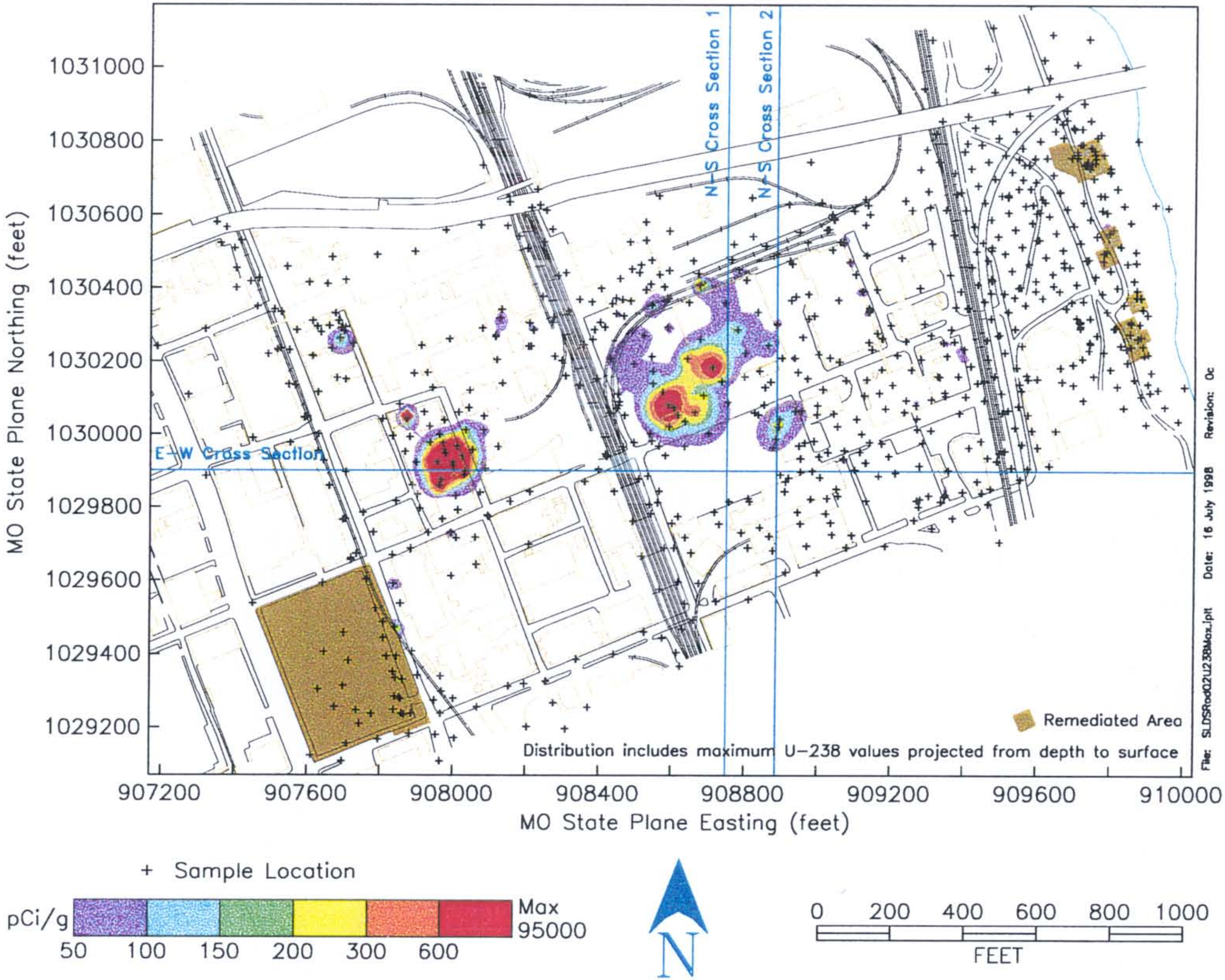

Figure 5-3. Extent of U-238 Contamination at SLDS

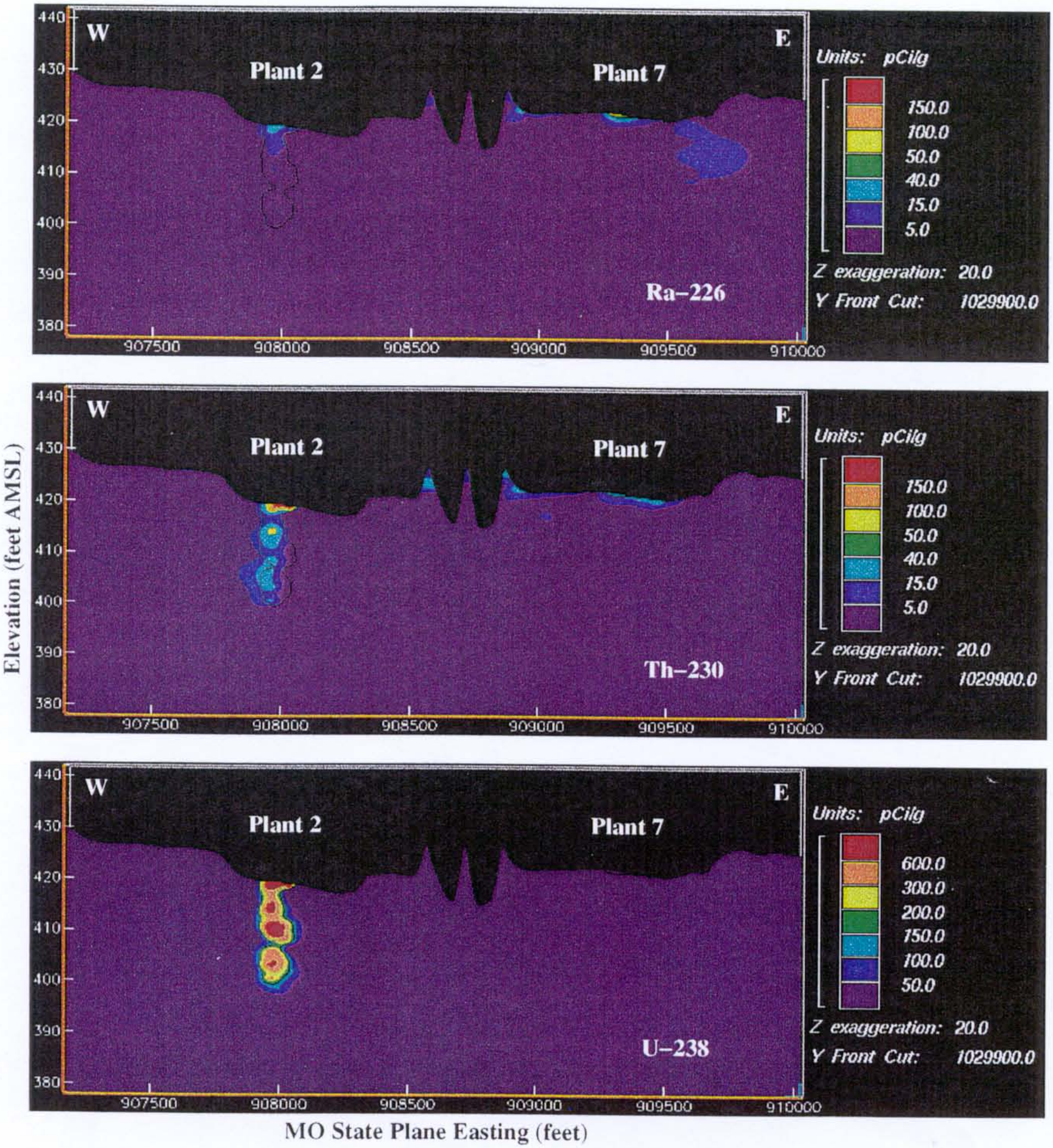

Figure 5-4. Vertical Extent of Contamination at SLDS (East-West Cross Section through Plant 7 and 2)

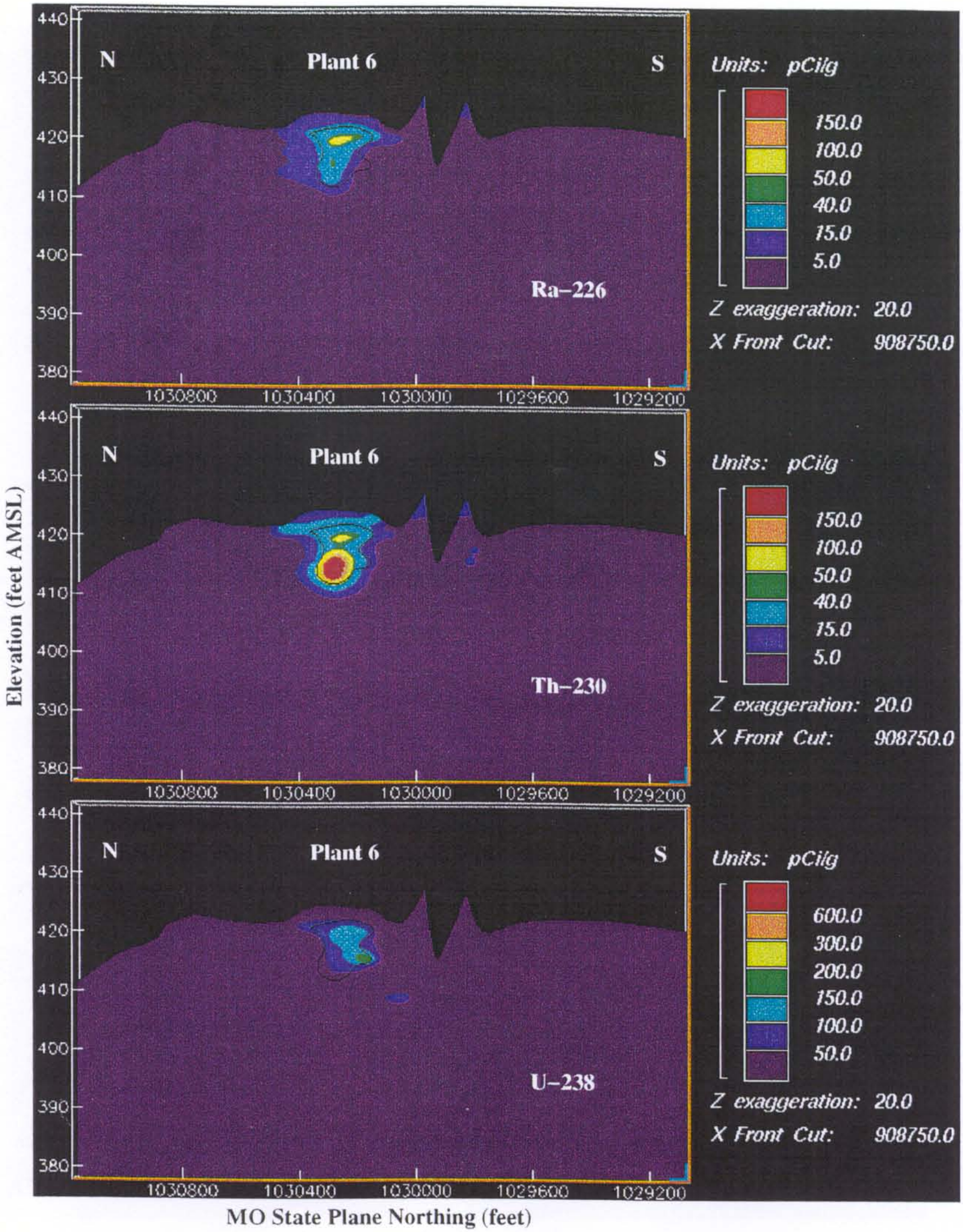

Figure 5-5. Vertical extent of contamination at SLDS North-South Cross Section through Plant 6

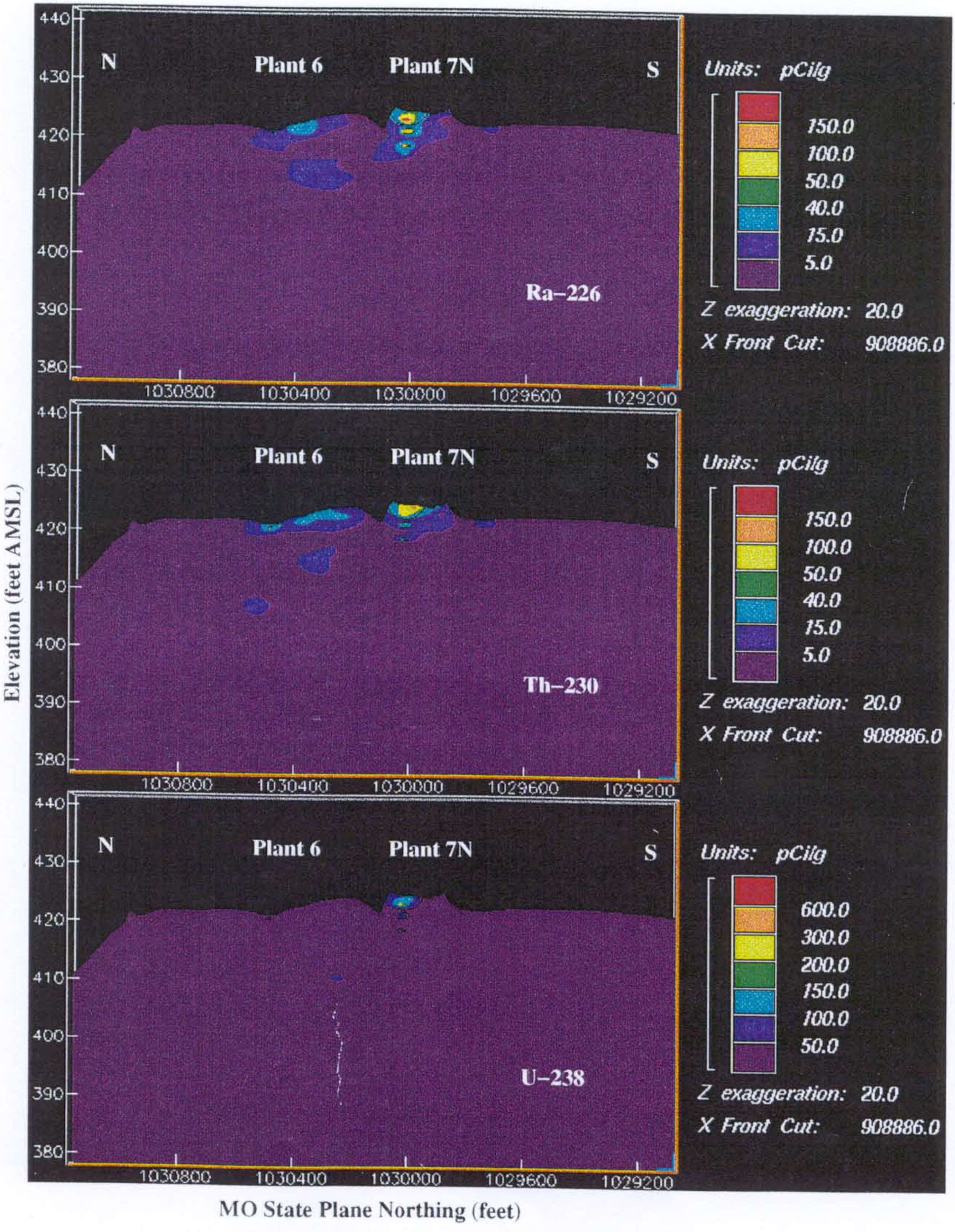

Figure 5-6. Vertical Extent of Contamination at SLDS (North-South Cross Section 2 through Plants 6 and 7

Production of Mallinckrodt products, and uranium processing activities may also have contributed. Based on ore assays, waste analyses, and risk assessment, the metals identified in the FS that may pose a risk and may have AEC/MED origins include arsenic, cadmium, copper, nickel, and uranium.

Table 5-1 summarizes the relevant metal and chemical data from the remedial investigation. Nickel was not detected in the 171 samples at values above average U.S. background (40 mg/kg). Copper was detected in 40 of 171 samples and ranged in concentration from 114 to 1120 mg/kg.

Arsenic was detected in 46 of 171 samples acquired from across the site. The detection limit for arsenic was relatively high, but it was sufficient to distinguish that arsenic is widely distributed, occurring both with other MED/AEC contaminants and randomly distributed across the site. Thirty background samples were collected near the SLDS and arsenic was detected in each in concentrations ranging from 4 to 27 mg/kg (SAIC 1998). While arsenic was identified as being present in the original uranium ore, no clear association could be discerned between the presence of arsenic and the location of MED/AEC radiological constituents. Figure 5-7 shows the distribution of arsenic.

There were 76 detections of cadmium in 171 samples. Soil concentrations ranged from less than 1 mg/kg to 44 mg/kg. As indicated in Figure 5-7, the distribution was both commingled with other MED/AEC contamination and random throughout SLDS independent of other MED/AEC contaminants. Cadmium was detected in 9 of 30 background samples with values up to 3.8 mg/kg (SAIC 1998).

Uranium is characterized based on both its chemical and radiological properties. Site characteristics are addressed as a radiological constituent.

Distribution of Organic Compounds in Soil

Organic compounds commonly found in industrial areas were detected in very low concentrations across the property; approximately two-thirds of these are PAHs. Base/neutral and acid extractables, identified as PAHs, were found in higher concentrations (ranging from 310 to 300,000 µg/kg) than were VOCs, but they are typically not very mobile in soil. No pattern of PAH distribution in soil was discernible across the site; these compounds are randomly distributed. In addition, no evidence has been found that any MED/AEC process used or generated PAHs. Data reviewed included all available information on site history and processes, and analysis of 30 off-site background samples (SAIC 1998). PAHs were detected in 25 of 30 background samples with concentrations to 14,000 µg/kg. Borings exhibiting the highest concentrations of PAHs were widely spaced across the site in Plants 1, 7W, and 10 (BNI 1990). PAHs are widespread in any urban area which has been subject to industrial development since the mid-1800s, and thus can not be attributed to a single process. The PAHs that occurred with the greatest frequency at the site are those associated with coal and coal combustion residues.

One of the last steps in the production of uranium metal at the Mallinckrodt facility was to cast the uranium into the form of hemispheres which resembled derbies. Therefore, the cast uranium hemispheres were known as uranium derbies, or derbies. A single reference from the late 1950's indicated that trichloroethene may have been used to clean uranium derbies (Harrington and Ruehle, 1959) which were produced in the Plant 6 area. No information was provided on the amount of TCE used or length of time over which it was used.

Table 5-1. Distribution of Potential Chemical COCs Detection

Analyte	Detections / # Samples	Minimum	Maximum	Average Detection
Plant 1				
Arsenic (mg/kg)	ND/1	ND	ND	ND
Cadmium (mg/kg)	1/1	16.1	16.1	16.1
Copper (mg/kg)	1/1	203	203	203
Nickel (mg/kg)	ND/1	ND	ND	ND
Plant 2				
Arsenic (mg/kg)	3/13	63.1	65.9	64.9
Cadmium (mg/kg)	5/13	0.97	1.9	1.15
Copper (mg/kg)	1/13	167	167	167
Nickel (mg/kg)	ND/13	ND	ND	ND
Plant 6a				
Arsenic (mg/kg)	ND/4	ND	ND	ND
Cadmium (mg/kg)	3/4	1.40	15.2	5.13
Copper (mg/kg)	2/4	101	113	107
Nickel (mg/kg)	ND/4	ND	ND	ND
Plant 6b				
Arsenic (mg/kg)	4/6	44.60	69.8	60.6
Cadmium (mg/kg)	2/6	3.60	5.5	2.3
Copper (mg/kg)	2/6	109	350	230
Nickel (mg/kg)	ND/6	ND	ND	ND

Table 5-1. Distribution of Potential Chemical COCs Detection (Cont'd)

Analyte	Detections / # Samples	Minimum	Maximum	Average Detection
Plant 6c				
Arsenic (mg/kg)	1/1	84.4	84.4	84.4
Cadmium (mg/kg)	ND/1	ND	ND	1
Copper (mg/kg)	ND/1	ND	ND	ND
Nickel (mg/kg)	ND/1	ND	ND	ND
Plant 7				
Arsenic (mg/kg)	ND/4	ND	ND	ND
Cadmium (mg/kg)	3/4	1.7	3.6	2.47
Copper (mg/kg)	2/4	239	482	361
Nickel (mg/kg)	ND/4	ND	ND	ND
Remainder of Site				
Arsenic (mg/kg)	38/142	40.7	200	64
Cadmium (mg/kg)	62/142	0.95	44.1	2.25
Copper (mg/kg)	32/142	114	1120	289
Nickel (mg/kg)	ND/142	12.6	24.4	20.3

ND = Not Detected

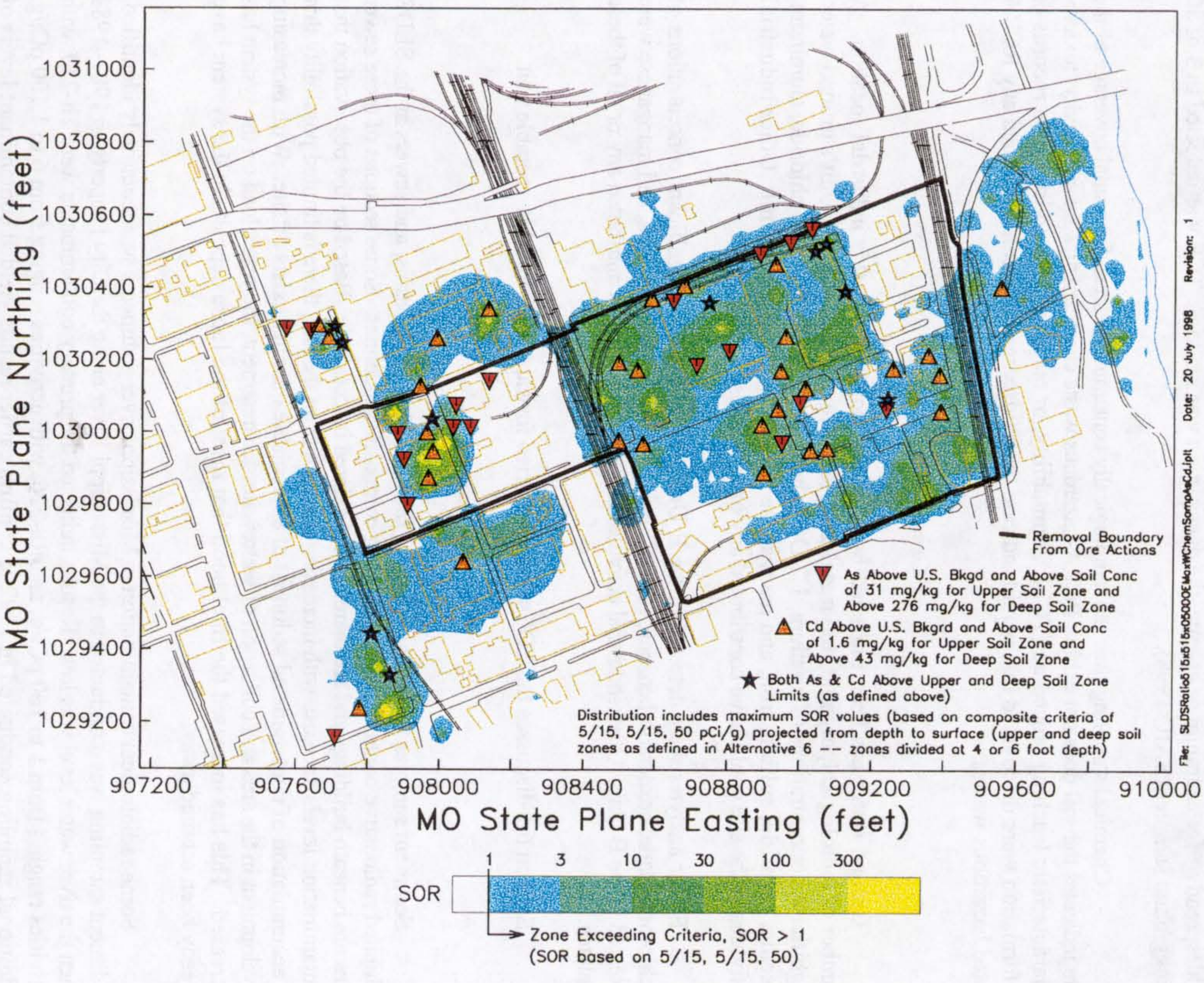

Figure 5-7. Distribution of Metal COCs at SLDS

At least forty-one samples for TCE were acquired from within or near where MED/AEC activities were known to have taken place. Eight detections of TCE were reported. While not as widespread as for cadmium or arsenic, the distribution was random. TCE was detected in 3 of 30 background samples (SAIC 1998).

Chemical sampling over the radiologically contaminated areas for spatial coverage of the site indicates the soil does not exhibit RCRA-hazardous waste characteristics for corrosivity, toxicity characteristic leaching procedure (TCLP), ignitability, or reactivity. In addition, no records or information were discovered that would indicate the environmental media contained any RCRA listed hazardous wastes.

Ground Water

Ground water has been impacted by processes conducted at this industrial location. A number of radiological, organic, and metal analytes were detected in the A Unit's ground water. Significant concentrations of uranium, 1,2-DCE, benzene, PCE, TCE, vinyl chloride, aluminum, arsenic, chloride, sulfate, iron, and manganese were detected in the A Unit. Other industrial activities at the site could have contributed any or all of these analytes.

Fewer analytes were detected in the B Unit's ground water. Significant concentrations of dichloromethane, hexachlorobenzene, 1,2-DCE, vinyl chloride, chloride, iron, and manganese were detected in the B Unit. Other industrial activities at the site could have contributed any or all of these analytes.

Section 6.1 discusses the COCs that are carried forward as part of this operable unit.

Sediments

Sediment samples taken from some of the manholes, catch basins, and sewers at the SLDS exhibited radioactive contamination exceeding composite guidelines. Some sections of these sewer lines are beneath buildings and are therefore considered inaccessible. Based on the observation that contamination levels decrease with increasing distance from the site, there is limited possibility that an accumulation of contaminated sediment of appreciable quantity exists offsite. With increasing development in the area and collection of wastewater for treatment, the water load on the system has increased. This has increased the likelihood that most of the loose deposits in the system have already been scoured away.

Some radiological contamination in Mississippi river sediments was tentatively identified. Sediment sampling was conducted in the Mississippi River along the City Property in 1987–1988 when the river water level was low. Results indicated the primary contaminants were Th-230, with activities ranging from 1 to 160 pCi/g, and Ra-226, with activities ranging from 6 to 1,100 pCi/g. Additional sampling conducted in 1992 to confirm earlier results yielded contaminant levels of <1 pCi/g for both Th-230 and Ra-226. It is suspected that periods of high water between 1988 and 1992 washed the contaminants in the sediment downstream.

6 SUMMARY OF SITE RISKS

A Baseline Risk Assessment (BRA) (DOE 1993) was conducted to evaluate potential risks to human health and the environment from the radioactive and non-radioactive contaminants at the site without regard to the source of contamination. In accordance with EPA guidance, both cancer and non-cancer toxic effects were evaluated for reasonable maximum exposures (RME). The assessment evaluated the potential risks that could develop without cleanup and assumes there are no protective controls in place, such as fencing to control access. In addition, possible effects on animal and plant species (ecological risk) were considered.

The purpose of the BRA is to determine the need for cleanup and to provide a baseline against which the remedial action alternatives are compared. The complete BRA report is available from the Administrative Record File for this site. A brief summary is provided here.

The BRA identified the routes by which people and the environment may be exposed to contaminants present at the SLDS. The SLDS has been industrial for over 100 years. The area is zoned “K” (unrestricted district) by the City of St. Louis. This category allows all uses except residential. Although there are residences near SLDS, the long-term plans for the area are to retain industrial uses, encourage the wholesale produce district, and phase out junk yards, truck storage lots, and the remaining residential uses. Based on past use, present zoning, and long-term planning, future use is most likely to remain industrial as well. Although future residential use is plausible, but unlikely, as a conservative measure the baseline risk assessment evaluated this scenario. Thus risks were calculated for current industrial and construction use and future residential use. In addition, recreational use of the City Property was evaluated. Pathways included external exposure to gamma radiation, particulate and radon inhalation, incidental soil ingestion, and dermal contact. In addition, for the future resident, ingestion of, inhalation of, and dermal contact with ground water were evaluated as well as ingestion of food from a garden grown in contaminated soil. It is the commercial/industrial scenario which is considered the reasonable future use upon which this remedial action is based. The results of the baseline risk assessment are summarized in Section 6.2.

Mathematical models were used to predict the possible effects on human health and the environment from exposure to radionuclides and chemicals for both present and future uses at the site. The results of the BRA were developed using the EPA required reasonable maximum exposure concentrations (representing the highest expected exposures) of the contaminants present at the site. The modeled risk estimates were then compared to an EPA-established “target risk range” for incremental cancer incidence (ie, the excess probability that an individual would develop cancer over a lifetime as a result of being exposed to the contamination at the site) to determine if remediation is warranted. A cancer risk greater than 10^{-4} or a hazard index (HI) greater than1.0 are generally considered unprotective and require action. HIs are calculated using reference doses and represent the possibility of developing non-cancer health effects. A hazard index of less than one indicates no adverse noncarcinogenic health effects are expected due to site contaminants.

The BRA used the available analytical data to characterize the risks associated with the SLDS. Data were obtained on organic and nonradioactive inorganic chemicals and radionuclides irrespective of whether they were associated with MED/AEC uranium activities. Limited ground-water data for the SLDS were evaluated without regard to background levels in ground water; this may have resulted in the BRA analysis overestimating the number of site-related anthropogenic and naturally occurring contaminants of concern. Consequently, this could have resulted in elevated risk estimates.

6.1 CONTAMINANTS OF CONCERN

The principal risk concern at the SLDS is exposure to radioactivity. There are three decay series that must be considered; U-238, Th-232, and U-235 (ie, the uranium, thorium, and actinium decay series, respectively). Radiological COCs were derived from these decay series based on their presence on the site and associated risk. As there are many progeny within the decay series, EPA Slope Factors derived in accordance with Risk Assessment Guidance for Superfund include short-lived progeny as a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen for radionuclides. The slope factors for radionuclides incorporate applicable radioactive decay and ingrowth of radioactive decay products.

Table 6-1 identifies the Preliminary Remediation Goals for potential non-radiological COCs developed specifically for the SLDS using EPA guidance. The FS identified four potential, non-radioactive COCs: arsenic, cadmium, copper, and nickel. Derivation of chemical COCs was accomplished by definition of the scope of MED/AEC actions at the SLDS including assessment of ore constituents and materials used in the processing of the ores to extract uranium. The concentration and distribution of potential COCs derived within the scope of the remediation were then compared to applicable CERCLA risk criteria based on the anticipated future industrial land use. Cadmium and arsenic were retained as COCs based on this process with emphasis on potential risk at the site. Additional evaluation eliminated nickel and copper as COCs as they are not of sufficient concentration, distribution, and toxicity to be considered COCs. Although TCE was not identified as a PCOC in the FS, the same rationale applies. Uranium, although addressed primarily due to its radiological characteristics, also presents chemical (heavy metal) risk to the kidneys and is retained as both a radiological and non-radiological COC.

Table 6-1. Risk-Based Soil Concentrations for Industrial/Construction Workers in the Workplace: St. Louis Downtown Site

	Risk-based soil concentrations (Cancer Risk/Hazard Quotient) (mg/kg)		
Chemical	10^{-6}/.1	10^{-5}/1	10^{-4}/3
Arsenic	0.69/5.7	6.9/57	69/171
*Cadmium	1.7	17	52
*Uranium	150	1,501	4,504

Concentrations shown here exceed those indicated in the FS due to FS use of an erroneous soil ingestion rate of 480 mg/day rather than the correct value of 136 mg/day. PRGs for carcinogens are the lower of carcinogenic and noncarcinogenic values based on either risk of 1E-6 or a HI of 1. Final soil cleanup levels are presented in Section 9, The Selected Remedy of this Record of Decision.

*****Uranium and cadmium concentrations are for noncarcinogenic effects. Cadmium is not carcinogenic for oral or dermal exposures and inhalation would not result in risk above the NCP threshold for this site. Carcinogenic effects of uranium are addressed with radiological PRGs and cleanup levels.

In summary, this ROD addresses both chemical and radiological contaminants. Radiological COCs for the SLDS consist of U-238 and its daughters, especially Th-230 and Ra-226, U-235 and its decay products, including protactinium-231 and actinium-227, and Th-232 and its progeny. Chemical COCs are cadmium, uranium and arsenic. Other constituents were detected and are being addressed pursuant to other environmental remediation processes and/or efforts.

6.2 BASELINE RISK

Three exposure scenarios were evaluated using baseline data from the St. Louis Downtown Site and are summarized in Table 6-2 to demonstrate the need for action. Baseline is defined here as the site characteristics prior to remediation. The scenarios include a future resident (future plausible, but unlikely, potential receptor), a commercial/industrial worker (current and most likely future receptor), and a construction worker (plausible worker conducts infrequent deep soil excavations). It is the commercial/industrial scenario which is considered to be the reasonable maximum exposure. The commercial/industrial worker is a full-time on-site employee who periodically performs subsurface excavations. The construction worker is an individual who receives a one time exposure to deep materials. Table 6-2 summarizes risk calculations for each receptor. Results for the residential scenario include information from the BRA (DOE 1993) that represent exposure over the entire site. The residential scenario is provided for the purpose of comparison only because the selected remedy assumes that the site will remain an industrial facility under institutional control. Exposure pathways for the resident include external gamma, soil ingestion, dust inhalation, and ground water consumption. Results for the commercial/industrial and construction workers are taken from the FS and include the results from the highest risk estimates from an assessment of six exposure units. The BRA did contain an evaluation of potential risks to an industrial worker and a construction worker. This evaluation was updated in the FS using site-specific information that was not available during the BRA. Exposure pathways for the commercial/industrial and construction workers include external gamma, soil ingestion, and dust inhalation. Risk calculations assume reasonable maximum exposure conditions that tend to overestimate actual risk.

Table 6-2 lists the risks to potential receptors from the primary radiological and non-radiological MED/AEC related COCs including actinium- (Ac) 227, protactinium- (Pa) 231, Ra-226, Th-230, Th-232, U-238, arsenic, and cadmium (note that uranium is listed as a radionuclide and a chemical because it is both a carcinogenic and toxic hazard). Also listed are the pathways that create the largest hazard as measured by the hazard index.

Results indicate that the radiological constituents contribute the most significant risk to potential receptors at SLDS. In the unlikely event the site reverts to residential use, the total risk is estimated as approximately 2×10^{-2}. Assuming the site remains an industrial facility (the intended land use), a commercial/industrial worker could receive a lifetime risk of approximately 5×10^{-3} and a construction worker that digs into site soils could receive a lifetime risk of approximately 9×10^{-4} if existing worker protection programs are discontinued. All baseline risk estimates exceed the CERCLA target risk range of 10^{-4} to 10^{-6}. Results from hazard index estimates indicate that the target hazard index of 1.0 would be exceeded under the residential scenario (HI = 18) and commercial/industrial scenario (HI = 2.3).

Table 6-2. Baseline Risk at SLDS

Analyte [a]	Primary Pathway [b]	Residential [c]	Commercial/Industrial [d]	Construction [d]
Baseline Risk for Radionuclides by Exposure Scenario				
Ac-227	Inhalation	1×10^{-3}	1×10^{-4}	3×10^{-7}
Pa-231	Inhalation	3×10^{-4}	8×10^{-6}	3×10^{-8}
Ra-226	External gamma	1×10^{-2}	2×10^{-3}	3×10^{-6}
Th-230	Inhalation	1×10^{-4}	2×10^{-4}	2×10^{-7}
Th-232	External gamma	2×10^{-3}	1×10^{-4}	4×10^{-6}
U-238	Inhalation	1×10^{-3}	2×10^{-3}	9×10^{-4}
Total Risk from Radionuclides		2×10^{-2}	5×10^{-3}	9×10^{-4}
Baseline Risk and (Hazard Index) for Non-Radionuclides by Exposure Scenario [e]				
Arsenic	Ingestion	3×10^{-3} (12)	5×10^{-5} (0.3)	3×10^{-7} (<< 0.01)
Cadmium	Ingestion[f]	1×10^{-8} (0.3)	9×10^{-8} (0.005)	2×10^{-10} (<< 0.01)
Uranium	Ingestion	See above (6)	See above (2)	See above (0.01)
Total Carcinogenic Risk from Chemicals		3×10^{-3}	5×10^{-5}	3×10^{-7}
Total Hazard Index (HI)		(18)	(2.3)	(0.01)
Total Carcinogenic Risk from All Radiological and Non-Radiological Sources [g]				
Total Carcinogenic Risk		2×10^{-2}	5×10^{-3}	9×10^{-4}

[a] Includes relevant decay products and associated radionuclides. For example, Pb-210 is included with Ra-226; Ra-228 and Th-228 are included with Th-232; and U-234 and U-235 are included with U-238.
[b] Pathway resulting in largest contribution to risk or hazard index is listed. Pathways include direct gamma, soil ingestion, dust inhalation, and ground water ingestion (resident only).
[c] From the Baseline Risk Assessment (DOE 1993)
[d] From the St. Louis Downtown Site Feasibility Study (USACE 1998). The Baseline Risk Assessment also included industrial and construction scenarios. Those scenarios, however, were revised for the Feasibility Study to incorporate site-specific information not available at the time of the Baseline Risk Assessment. Six exposure units were evaluated in the Feasibility Study. The highest (most conservative) risk from those exposure units is listed for the commercial/industrial and construction workers.
[e] The hazard index is provided in parentheses (HI)
[f] Cancer risk for Cd from inhalation pathway only. The primary ingestion pathway is due to noncarcinogenic efforts.
[g] The total carcinogenic risk is provided here as per OSWER Guidance Directive 9400.4-18.

All risk estimates are rounded to one significant digit. Reported values may contain round-off error.

Ground water beneath the site is not currently used for any purpose and, after 45 years since uranium production ceased, does not contain hazardous levels of the COCs addressed in this ROD in the potentially usable B Unit.

The substantial variations in correlations between Ra-226 in soil and Rn-222 preclude accurate modeling of indoor radon in industrial structures especially if such structures do not have basements. No buildings currently exist within the OU. Actual radon concentration anticipated in structures to be built on site are currently indeterminate but could be significant. Radon concentrations must, therefore be measured in any such structure and the associated risk assessed individually based on such measurements after buildings they are constructed.

6.3 ECOLOGICAL RISK

An ecological risk assessment was conducted to evaluate potential effects from contamination at SLDS. Due to the urban environment, the SLDS has limited wildlife habitat and biotic diversity. The ecological assessment compared contaminant concentrations detected in various media (soil, sediment, and water) at the site with literature on contaminant toxicity to biota. This study indicated that only arsenic, thallium, and PAHs are at concentrations in soil that could potentially impact biota, and of these, only arsenic could be associated with uranium ores or uranium processing. Since habitats are unlikely even in the future, the ecological assessment concluded that the significance of the St. Louis site with regard to ecological resources is minimal, and that potential human health effects would determine the need and levels for cleanup (DOE 1993).

7 DESCRIPTION OF ALTERNATIVES

A Feasibility Study was prepared to evaluate potential remedial action alternatives for the SLDS. Remedial alternatives were evaluated in accordance with the requirements of CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The evaluation of remedial action alternatives for the site included identifying remedial action objectives specific to the contaminated environmental media, identifying general response actions (GRAs) required to attain the remedial action objectives for the site, identifying and screening technologies and process options applicable to these GRAs, and evaluating the screened process options with regard to their effectiveness, implementability, and cost. The purpose of the final screening step was to develop a set of site-wide alternatives for detailed analysis.

Modeling indicates that loss of current controls would present an unacceptable risk to industrial/construction workers, although actual current risks at SLDS are protective for on-site industrial workers. The risks from MED/AEC contaminants, primarily radionuclides, must be addressed to eliminate direct contact of on-site industrial/construction workers with surficial contaminants, since risk could be expected to exceed CERCLA protectiveness criteria. Further, the residual site risk from the anticipated industrial land use, including excavation of soils in support of on-site construction and development, must be protective under CERCLA.

7.1 REMEDIAL ACTION OBJECTIVES

Remedial action objectives specify unit-specific contaminants, media of concern, potential exposure pathways, and remediation goals. Remedial action objectives are based on the nature and extent of contamination, threatened resources, and the potential for human and environmental exposure. Throughout the characterization process, preliminary remediation goals are modified as information concerning the unit and potential remedial technologies becomes available. Final remediation goals, which establish acceptable exposure levels protective of human health and the environment, are determined when the remedy is selected.

Media-specific remedial action objectives were developed for SLDS for soil and ground water. In general, mitigation of the exposure pathways of concern and compliance with ARARs provide a framework for media-specific remedial action objectives. Media-based remedial action objectives are discussed below. Potential environmental pathways warranting mitigative measures are:

- Direct contact with soils through ingestion and dermal contact,
- External gamma radiation from the surface soil (Risks are minimal for gamma radiation from subsurface soil containing radionuclides based on the shielding provided by clean surface soils.),

- Inhalation of fugitive dust and radon gas emissions from soils, and

- Ingestion of ground water. The risk from this exposure is remote since existing impacts do not affect usable ground water and migration to potentially usable ground water is not expected. Ground water is not currently used as a potential drinking water source, ground water is of poor quality, yields in the bedrock are poor, and the area has abundant surface water which makes future ground water use unlikely. This site is being remediated for industrial land use. Many of the anthropogenic compounds detected in the A Unit are not found in the B Unit suggesting little or no migration from the A Unit is occurring.

Soils at SLDS were characterized in the BRA as posing potentially unacceptable risks to human health and the environment due to the following MED/AEC related radiological COCs: Th-230, Th-232, Ra-226, Ra-228, U-235, U-238, and their respective radioactive decay products. Non-radiological COCs that may have been introduced by MED/AEC operations include arsenic and cadmium in uranium ore processing areas. The primary contribution to risk from uranium at this site results from its radioactivity. However, because uranium is a toxicant in addition to being a radionuclide, it is included in both the radiological and non-radiological categories. Remedial alternatives developed to address contamination in soils should consider elimination or mitigation of the exposure pathways listed above as well as compliance with guidelines (Table 7-1).

Table 7-1. Remedial Action Objectives for Remediation of the SLDS Operable Unit

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

7.2 GENERAL RESPONSE ACTIONS (GRAS)

The toxicity of radionuclides cannot be reduced through treatment and treatment for stabilization and volume reduction purposes has not been found to be effective in this case. Therefore, GRAs considered for SLDS are limited to no action, institutional controls, containment, excavation and disposal. Excavation and disposal could be implemented based on unrestricted future land use or based on anticipated future industrial land use with numerous possible variations of each of these general approaches, predicated on CERCLA modifying criteria including community and state participation. Each action may include several technology options. The GRAs are structured to achieve protectiveness for human health and the environment and applicable remedial action objectives.

Remedial action technologies that could be used to implement GRAs were identified and evaluated in detail in the Initial Screening of Alternatives (ISA) report for the St. Louis site (DOE 1992). The ISA, which is one of the St. Louis site's primary CERCLA documents, was prepared prior to the FS for the purpose of performing an initial screening of the available technologies for the contaminated media. In the ISA the universe of available technologies was narrowed to only those applicable to St. Louis site media, contaminant types and concentrations, and site-specific conditions. Chapter 2 of the ISA presents the remedial options considered along with a short description of the process option and evaluation of the available technologies effectiveness, implementability, and cost. Although not specifically called a technology, replacement of contaminated material with clean fill effectively blocks the gamma pathway. Fifteen to thirty centimeters (6 to 12 in.) of fill, reduces gamma radiation of the energies involved to essentially nondetectable levels. These factors are considered as follows:

- technologies are evaluated for effectiveness in terms of protecting human health and the environment in both the short-term and the long-term, and in reducing contaminant toxicity, mobility, and/or volume;

- technologies are evaluated for implementability in terms of technical feasibility, administrative feasibility, and resource availability; and,

- technologies are evaluated for cost in a comparative manner (ie, low, moderate, or high) for technologies of similar effectiveness or implementability.

The ISA document identifies potentially viable technologies and processes retained for consideration as components of the media-specific alternatives. Retained technologies are subsequently combined to form a broad range of alternatives for each medium. In the ISA, Chapter 3 identifies the alternatives that were considered for further evaluation during the FS development and screening of alternatives.

7.3 REMEDIAL ACTION ALTERNATIVES

Remedial action alternatives for the OU were evaluated using the criteria established under CERCLA to assure that the remedial action is protective of human health and the environment. Sitewide alternatives were developed to cover a wide range of options that address the source media of concern for the SLDS and provide overall protection of human health and the environment. A "no-action" alternative was evaluated in accordance with CERCLA to provide a baseline for comparison.

Given that excavation and remote disposal is generally the only viable option for the SLDS and that cleanup level is the only major variable left to evaluate, Alternatives 4, 5, and 6 below were developed essentially from the same general alternative, i.e., excavation and remote disposal. It was considered appropriate in this case to compare varying degrees of excavation.

Sitewide remedial action alternatives for the SLDS selected for detailed evaluation are:

- Alternative 1 – No Action
- Alternative 2 – Institutional Controls and Site Maintenance
- Alternative 3 – Consolidation and Capping
- Alternative 4 – Partial Excavation and Disposal
- Alternative 5 – Complete Excavation and Disposal
- Alternative 6 – Selective Excavation and Disposal

To make costs comparable across all alternatives, the cost of addressing inaccessible soils is included in the costs for Alternative 3, 4, and 6, although this in not actually a part of the scope.

All of the action alternatives are considered protective of ground water and include the implementation of a long-term ground-water monitoring program to demonstrate the effectiveness of the source removal action. Agreements with the state and local water authorities to restrict the installation of wells within a specified area could be used to control ground water use.

The sitewide remedial alternatives are described in detail in the FS, which is available in the Administrative Record File, and summarized in the following sections. The various components of the remedial action alternatives discussed here are considered representative of the general technologies that define the alternatives.

7.3.1 Alternative 1 – No Action

The no-action alternative was developed to provide a baseline for comparison with other alternatives in compliance with CERCLA requirements. This alternative consists of performing no remedial actions and maintaining a "status quo" at the site. Therefore, no soil would be removed. Buildings and structures would continue to be used and operated as is currently being done; and routine monitoring of air, buildings, ground water, and storm water, would continue. The NCP requires that a No Action alternative be included to serve as a basis for comparison with other alternatives.

Alternative 1 does not comply with ARARs. Residual radionuclide concentrations in soil would continue to exceed guidelines. No reduction of risk would be realized under the No Action alternative.

The present value for Alternative 1 would be approximately $22 million.

7.3.2 Alternative 2 – Institutional Controls and Site Maintenance

Under this alternative, institutional controls and site maintenance would be implemented to prevent significant exposure to site contamination. Institutional controls would include land-use restrictions, maintenance, and ground-water use restrictions through ground-water use advisories. Missouri regulation could be used to limit drilling wells for drinking water in areas of known contamination. Site maintenance would include surveillance of land, restricted ground-water use, environmental monitoring of affected media, and implementing minimal engineering controls such as radon abatement. Site security, including fences and signs, is already maintained at most of the SLDS properties, including 24-hour security at the Mallinckrodt, Inc. Plant. Mallinckrodt's health and safety plan would continue to protect onsite employees. Barriers, such as fencing and posted signs, would be employed at other areas such as the city property and accessible areas of VPs.

The objective of environmental monitoring is to measure contaminant concentrations, location, and movement. The B Unit would be monitored for OU COCs. A long-term monitoring plan would be developed to measure the effectiveness of passive collection systems for newly constructed buildings.

This alternative would be protective of human health and the environment and comply with ARARs as long as institutional controls are maintained. The 30-year cost for Alternative 2 would be approximately $29 million.

7.3.3 Alternative 3 – Consolidation and Capping

Soil excavated to composite criteria (ARAR-based) as defined in Section 7.3.7 would be consolidated and covered with a low permeability cap at a suitable location onsite. The property associated with the consolidated pile would be acquired by the federal government. Either the city property or the area formerly occupied by the 50 series buildings at Plant 2 could be used. Plant 2 covers approximately 2 hectares (5 acres). To determine costs, it was assumed that the cap would be low permeability and consist of all-natural materials, no synthetic liners or other man-made materials.

The potential for subsidence over the proposed area to be capped would be evaluated during remedial design. Remedies to prevent uncontrolled subsidence would be employed as required to stabilize the cap area. Costs for these actions are included in the Alternative 3 cost analysis.

A long-term management plan would be developed to address notification requirements for property owners as well as monitoring and maintenance requirements into the future. This plan would include provisions addressing how property owners should contact the agency responsible for long-term control of impacted areas and how these areas will be reviewed, maintained, and monitored by the federal government after completion of Alternative 3.

The cap system reduces the potential for human exposure, for migration of contaminants into surface water and ground water, and for generation of fugitive dust. Capping is an effective means of preventing human exposure to underlying contaminated materials.

Alternative 3 would be protective of human health and the environment and comply with ARARs through use of institutional controls to restrict and regulate access to capped soils.

The 30-year cost for Alternative 3 would be approximately $100 million. This cost includes the inaccessible soil and building decontamination in order to provide comparability across the alternatives.

7.3.4 Alternative 4 – Partial Excavation and Disposal

This alternative includes excavation of accessible contaminated soil on the Mallinckrodt property to two feet and on VPs to depth based on the composite criteria (ARAR-based). Soils on the Mallinckrodt property from two feet to depth are excavated to site specific deep soil risk based removal criteria. (See Section 7.3.7.1 for derivation of criteria). Residual risk is assessed at each plant area under anticipated future industrial use of the property. This alternative assumes a periodic continuing government role to support disposal of soils exceeding the composite criteria (ARAR based) below 2 feet in depth that are brought to the surface by excavation pursuant to Mallinckrodt construction efforts on-site. It also assumes site institutional controls and development of a long-term agreement between Mallinckrodt and the government with respect to responsibilities for residual soil exceeding the composite criteria (ARAR based).

Alternative 4 would be protective of human health and the environment and meet ARARs through the use of institutional controls to restrict access to the subsurface.

The 30-year cost for alternative 4 would be approximately $92 million. As with Alternative 3, inaccessible soils and buildings 25 and 101 are included in the estimate. Alternative 4 may include substantial additional future costs to the government for disposal of soils above composite criteria (ARAR-based) which are excavated pursuant to construction activities on the Mallinckrodt property. Inability to accurately define long-term construction activities precludes inclusion of these potentially significant costs in the cost estimate.

7.3.5 Alternative 5 – Complete Excavation and Disposal

This alternative consists of excavation and off-site disposal of all accessible soils above the composite criteria (ARAR-based). Chemical COC's that are within the scope of the ROD are also remediated.

As with Alternatives 3 and 4, excavation of the source material would be protective of the ground water. A monitoring program for ground water will be established and enforced until discontinued pursuant to five-year CERCLA reviews. Agreements negotiated with the state and local water authorities to restrict the installation of wells within a specified area could be used to prevent unauthorized use of ground water.

Alternative 5 would be protective of human health and the environment and meets ARARs.

The 30-year costs for Alternative 5 would be approximately $140 million, including inaccessible soils and building decontamination.

7.3.6 Alternative 6 – Selective Excavation and Disposal

This alternative excavates soils to composite criteria (ARAR based) on perimeter VPs, and Mallinckrodt Plant 7. Plant 10 was previously protectively addressed pursuant to a removal action to the composite criteria (ARAR based). Within the remainder of the OU, this alternative excavates accessible soils on the Mallinckrodt property to composite criteria (ARAR based) in the top 4 or 6 feet and to depth to deep-soil criteria (risk based). (See Section 7.3.7.1, Derivation of soil criteria).

This alternative also includes levee property which was previously addressed to protective recreational use standards pursuant to a removal action and is not subject to further action under this ROD. Only approved off-site borrow would be used to fill in the excavation at the perimeter VPs and in the top 4 or 6 feet across the Mallinckrodt property. Material below the deep-soil criteria (risk-based) could be used as backfill at depths greater than the composite criteria (ARAR-based) concentration depth. Thus, below 4 or 6 feet, material below the deep-soil criteria (risk based) would be replaced with material less than the deep-soil criteria (risk based) provided it does not exhibit a hazardous characteristic. (Hazardous characteristic tests would be conducted on samples of potential backfill from each excavation.) Potential ground water degradation would be controlled by: removal of sources of soil contamination; implementing institutional controls, when applicable; and perimeter ground-water monitoring in the B Unit to assure post remediation compliance.

For Alternative 6, excavation to the most stringent criteria proceeds to a depth of 6 ft in areas of the Mallinckrodt portion of the site located west of the St. Louis Terminal RR Association tracks and at the former locations of Buildings 116 and 117; excavation to the composite criteria (ARAR based) occurs at other areas of the site to a depth of 4 ft except the Plant 7 area and vicinity properties where the composite criteria (ARAR-based) are applied to depth.

Alternative 6 is protective of human health and the environment and meets ARARs (see Section 10). This alternative focuses on minimizing the need for future studies, design, and remedial actions in addition to protection of human health and the environment relative to Alternative 4. Deeper excavation to the composite criteria (ARAR based) and use of off-site borrow as backfill above 4 to 6 foot depths reduces potential risk to personnel supporting ongoing and future excavation on the Mallinckrodt property and eliminates potential costs to the government for future disposal of contaminated soil generated during excavation in support of construction. As future construction activities cannot be fully defined, the anticipated future costs to the government associated with disposal of these soils cannot be fully assessed at the current time and are, therefore, excluded from cost analysis. The 30 year cost for Alternative 6 would be approximately $114 million, including the cost of excavation and disposal of inaccessible soils and the cost of building decontamination.

7.3.7 Derivation of Remediation Criteria

7.3.7.1 Radiological

40CFR192 and criteria contained therein for residual radium and thorium serves as an ARAR (see Section 10, ARAR analysis). As such, 5 pCi/g of radium or thorium is used as a standard for these radioisotopes in the top 15 cm (6 inches) and 15 pCi/g of radium or thorium is used in any subsequent 15 cm (6 inch) soil layer to 1.2 or 1.8 m (4 or 6 ft) for remediation of the site. Based on contaminant distribution in the subsurface, application of the 15 pCi/g standard is expected to result in residual concentrations that average below 5 pCi/g, but confirmation of remediation completion will be in accordance with the 5/15 ARAR or supplemental standards, as appropriate. In conjunction with the site-specific risk assessment for radium and thorium, USACE developed site-specific supplemental standards for U-238 which with Ra-226 and Th-230, represent the major radioisotopes of interest.

This remedy must also incorporate all radiological contaminants of concern in the OU. To assure that all potential radiological contaminants of concern are addressed, the BRA Investigation included all pertinent radionuclides. In particular, rather than assume that Pa -231 and Ac-227 were in secular equilibrium with their U-235 parent, direct measurements were made of Ac-227. That data was then compared to other radionuclides to enable derivation of a statistical relationships between Pa-231, Ac-227, and other radionuclides. Analyses of data supported use of a conservative 1:2.5 ratio for Ac-227 to Ra-226. This approach, together with factors that account for inclusion of appropriate daughter activity with the parent nuclide, assures that the risk assessment performed to develop this remedy incorporates applicable radionuclides and activity. Remediation cleanup levels are derived for the primary site contaminants Ra-226, Th-230, Ra-226, Th-232 and U-238 as remediation of these radioisotopes would assure that all radioactive contaminants are addressed concurrently.

Derivation of cleanup guidelines for U-238 pursuant to 40 CFR 192.21(h) necessitates determination of the site specific NCP point of departure remediation goal (See Table 7-2) The combined effects of a number of qualifying factors “including but not limited to exposure factors, uncertainty factors, and technical factors” are then addressed if required to move away from the remediation goal point of departure.

Review of the point of departure (10^{-6}) remediation goal for U-238 (2.6 pCi/g) indicates that this value is within the range of site background concentrations (0.l59 to 3.78 pCi/g for 32 sample detects). The point of departure concentration also presents significant issues with respect to implementability. To enable field measurement of U-238, preclude the cost for over excavation of clean soils, and facilitate statistical confirmation of the cleanup, the remediation goal was adjusted upward to 50 pCi/g. This guideline is protective in that it corresponds to a risk of less than 2×10^{-5} without regard to clean cover. This value is a valid, supportable remediation criterion for this site given that actual residual concentrations are generally substantially less than the applicable criterion, and is further appropriate given the need to minimize over excavation of soils and the associated costs.

Table 7-2. Soil Preliminary Remediation Goals and Risk-Based Concentrations for Potential Radionuclides of Concern in SLDS Soils Based on a Long-Term Worker (Industrial/Construction) Scenario

Radionuclide	Cancer Risk			
	1×10^{-6} (PRG)	1×10^{-5}	1×10^{-4}	3×10^{-4} [(a)]
	PRG Concentration (pCi/g)			
Ac-227	0.2	2	21	64
Pa-231	0.2	2	22	65
Ra-226+D	<BKG	<BKG	4	11
Th-230	<BKG	<BKG	10	30
Th-232+D	<BKG	<BKG	3	7.6
U-235	0.8	8	80	239
U-238+D	2.6	26	262	787

Notes:
1. Exposure and intake parameters are based on references and Mallinckrodt site-specific assumptions as described in Appendix C of the Feasibility Study. The resultant concentrations are significantly more conservative than risk values derived using Risk Assessment Guidance for Superfund default values. For comparative purposes, concentrations calculated using RAGS equate to 99, 16, 47, 12 and 1200 pCi/g for Ac-227, Pa-231, Ra-226+D, Th-230, Th-232+D, and U-238+D respectively for the $3x10^{-4}$ risk level that EPA has determined equates to 15 mrem/y and is consistent with the high end of the acceptable risk range.
2. Calculations include contributions from decay and ingrowth of radioactive progeny to 1,000 yrs. The most limiting value for each decay chain is shown (ie, Th-232 includes the contributions from Ra-228, Th-228, and other progeny, and the PRG is based on the most limiting concentration in this decay series in the 1.000 year period).
3. <BKG indicates that the calculated PRG value is less than background for St. Louis site soils.

(a) EPA risk assessment guidance indicates that PRGs are typically for risks of $10^{-6.}$ However, OSWER Directive 9200.4-18 specifically indicates that 3×10^{-4} is considered consistent with the high end of the acceptable risk range.

D = daughters

As other nuclides are also present in most cases with U-238 it is necessary pursuant to 40 CFR 192.21 (h) to address the potential health effects of multiple contaminants. To concurrently address each of the major radionuclides of interest, a sum of the ratios calculation is applied as follows for Ra-226, Th-230 and U-238, the major radioisotopes of interest at this site:

$$\frac{\text{greater of Ra-226 or Th-230}}{5} + \frac{\text{greater of Ra-228 or Th-232}}{5} + \frac{\text{U-238}}{50} \text{(all isotopes above backgro}$$

in the top 15 cm (6 in) or

$$\frac{\text{greater of Ra-226 or Th-230}}{15} + \frac{\text{greater of Ra-228 or Th-232}}{15} + \frac{\text{U-238}}{50} \text{(all isotopes above backgro}$$

from the 6" to 4 or 6 feet. Taken together, these are called the composite criteria. Soil that meet the above criteria do not need to be removed.

This approach will result in excavation based on the primary isotope(s) of interest in each plant area and, given inclusion of U-238 and minimal quantities of Ra-228 and Th-232 on site, is fully protective and is expected to result in a more conservative remediation than the approach discussed in OSWER directives.

As previously noted, USACE also verified the appropriateness of the 5/15 pCi/g criterion for radium and thorium through a comprehensive review of residual contamination levels for Plant 10 (a portion of the SLDS previously remediated to the 5/15 criterion with a 50 pCi/g U-238 limit), and comparison of these results with EPA guidance. Table 7-3 presents the residual concentrations of radionuclides following the Plant 10 removal action.

Review of the data (which includes site background) clearly establishes that contaminant distribution in Plant 10 was such that remediation to criteria of 5/15 pCi/g for radium and thorium resulted in residual site, contamination below 5 pCi/g. Use of the 15 pCi/g subsurface standard is expected to result in a protective residual condition consistent with the land use at this site (USACE 1998a).

Table 7-3. Plant 10 Post Removal Summary Data

	Average (including background)	Std dev	Minimum	Maximum	Average Site Background
Ra-226 (pCi/g)	2.0	1.9	0.4	14	2.8
Th-230 (pCi/g)	4.9	3.0	1.4	26	1.9
U-238 (pCi/g)	20	35.1	0.8	290	1.4

*The standard deviation, minimum and maximum apply to the average residual concentration including background. Average site background is included for comparison (SAIC 1998). Data are rounded to two significant figures. Data were averaged over 100 square meters.
*The same uranium criteria as used in the current operable unit was used in the Plant 10 cleanup (50 pCi/g above background for U-238).

The composite criteria (ARAR based) were developed to address near-surface contaminated soils. The supplemental standards pursuant to 40CFR192.21 are invoked for contaminated soils at depths below two feet for Alternative 4 and below 4 or 6 feet for Alternative 6. Deep-soil criteria (risk-based) were derived to address deep soils which provide a more limited potential for exposure. Calculation of preliminary remediation goals for radium and thorium in deep soils under the industrial/construction worker scenario using 1×10^{-6} as the point of departure results in PRGs of less than 1 pCi/g. Development of a remediation design for cleanup levels in this range presents significant implementability and practicability problems, e.g. (1) cleanup goals are effectively indistinguishable from background (2) confirmation becomes statistically complex (3) inability to accurately measure main radionuclides of interest at concentrations approaching background will preclude field instruments.

Further, design and implementation factors systematically lead to over excavation and residual concentrations well below cleanup criteria (see confirmation results of Plant 10 cleanup). Development of the deep criteria accounts for predictable overexcavation by examining the risks posed by anticipated residual conditions (see Table 7-4). Application of criteria for radium and thorium of 50/100 pCi/g for deep soil will result in residual risks that are protective per the NCP risk range for all exposure units even under the hypothetical assumption that no cover is in place, and will minimize the amount of "clean" soil that will be excavated and transported offsite for disposal thereby improving cost-effectiveness. It will also comply with exposure criteria applicable in the event of loss of site controls.

Uranium cleanup guidelines were developed for deep soil, for soils two feet or more from the surface under alternative 4 and more than four or six feet under alternative 6, based on the anticipated continued industrial use of the sites. Use of the 10^{-6} remediation goal, point of departure of 2.6 pCi/g would present substantial implementability problems related to field measurement of concentrations approaching background, statistical comparison with background and costs of remediation associated with overexcavation of soils. A guideline of 150 pCi/g for U-238 represents a mid-point (5.7×10^{-5}) between 10^{-5} and 10^{-4} based on the assumption of no clean cover. Use of 150 pCi/g as a remediation goal would, with the existence of clean cover, assure protectiveness approaching the point of departure, especially given comparison between remediation goals and post remediation concentration.

Derivation of remediation criteria for soils two feet or more below the surface are based on the sum of Ra-226, Th-230, and U-238 concentrations, the primary radionuclides of interest, using Table 7-4. It is immediately apparent from this table that protective remediation of Plant 7 due to risk associated with elevated Ra-226 concentration necessitates use of composite criteria (ARAR based) to depth. Such remediation assures protectiveness and compliance with standards applicable in the event of loss of site controls. Remediation criteria of 50/100/150 pCi/g was developed using the following sum of the ratios in consultation with stakeholders:

$$\frac{\text{Ra-226}}{50} + \frac{\text{Th-230}}{100} + \frac{\text{U-238}}{150} \text{ (all isotopes above background)} < 1$$

Table 7-4. Industrial/Construction Cancer Risk Assessment Results in the Top 6 ft of Soil by Cover Depth

Removal Option	Risk by Exposure Unit - No Cover					
Ra-226/Th-230/U-238 (pCi/g)	Plant 1	Plant 2	Plant 6a	Plant 6b	Plant 6c	Plant 7
A: No Removal	3.6×10^{-3}	1.5×10^{-2}	2.8×10^{-3}	1.7×10^{-3}	6.2×10^{-4}	1.1×10^{-2}
B: 200/400/600	3.3×10^{-3}	4.2×10^{-4}	5.2×10^{-4}	9.0×10^{-4}	3.0×10^{-4}	3.8×10^{-3}
C: 100/200/300	2.7×10^{-4}	3.0×10^{-4}	6.9×10^{-4}	6.4×10^{-4}	3.0×10^{-4}	1.1×10^{-3}
D: 50/100/150 (Alt 6)	2.7×10^{-4}	1.8×10^{-4}	2.1×10^{-4}	3.5×10^{-4}	3.0×10^{-4}	1.1×10^{-3}
E: 15/40/100	2.7×10^{-4}	1.8×10^{-4}	2.6×10^{-4}	3.9×10^{-4}	3.0×10^{-4}	2.3×10^{-4}
F: Composite Criteria (SOR > 1)	3.5×10^{-5}	1.7×10^{-4}	2.3×10^{-4}	3.1×10^{-4}	8.6×10^{-5}	2.3×10^{-4}
Removal Option	Risk Exposure Unit - 6-Inch Cover					
	Plant 1	Plant 2	Plant 6a	Plant 6b	Plant 6c	Plant 7
A: No Removal	5.4×10^{-4}	2.2×10^{-3}	4.0×10^{-4}	2.5×10^{-4}	9.5×10^{-5}	1.7×10^{-3}
B: 200/400/600	5.0×10^{-4}	5.1×10^{-5}	7.6×10^{-5}	1.4×10^{-4}	4.8×10^{-5}	5.8×10^{-4}
C: 100/200/300	3.8×10^{-5}	4.1×10^{-5}	1.0×10^{-4}	9.7×10^{-5}	4.8×10^{-5}	1.7×10^{-4}
D: 50/100/150 (Alt 6)	3.8×10^{-5}	2.5×10^{-5}	$3.1 \times 1\ 0^{-5}$	5.3×10^{-5}	4.8×10^{-5}	1.7×10^{-4}
E: 15/40/100	3.8×10^{-5}	2.5×10^{-5}	4.0×10^{-5}	6.2×10^{-5}	4.8×10^{-5}	3.6×10^{-5}
F: Composite Criteria (SOR > 1)	5.1×10^{-6}	2.6×10^{-5}	3.4×10^{-5}	4.8×10^{-5}	1.3×10^{-5}	3.6×10^{-5}
Removal Option	Risk by Exposure Unit - 2-Ft Cover					
	Plant 1	Plant 2	Plant 6a	Plant 6b	Plant 6c	Plant 7
A: No Removal	1.8×10^{-6}	6.8×10^{-6}	1.3×10^{-6}	8.5×10^{-7}	3.3×10^{-7}	5.3×10^{-6}
B: 200/400/600	1.6×10^{-6}	1.8×10^{-7}	2.6×10^{-7}	4.6×10^{-7}	2.0×10^{-7}	1.9×10^{-6}
C: 100/200/300	1.2×10^{-7}	1.6×10^{-7}	3.5×10^{-7}	3.3×10^{-7}	2.0×10^{-7}	6.4×10^{-7}
D: 50/100/150 (Alt 6)	1.2×10^{-7}	9.7×10^{-8}	1.1×10^{-7}	2.0×10^{-7}	2.0×10^{-7}	6.4×10^{-7}
E: 15/40/100	1.2×10^{-7}	9.7×10^{-8}	1.5×10^{-7}	2.5×10^{-7}	2.0×10^{-7}	1.4×10^{-7}
F: Composite Criteria (SOR > 1)	1.6×10^{-8}	9.6×10^{-8}	1.2×10^{-7}	1.9×10^{-7}	4.6×10^{-8}	1.4×10^{-7}

Soil that meets this standard does not need to be removed. It represents a movement away from the 10^{-6} point of departure for remediation goals to the range of 2.5×10^{-5} to 5.3×10^{-5} with a 6 inch cover depending on the plant area.

Giving consideration to applicable clean cover for Alternative 4, use of this criteria would assure protectiveness given consideration of chemical COCs. For Alternative 6, use of off-site borrow as backfill to 4 to 6 feet across the site would result in residual site risk of less than the CERCLA 10^{-6} point of departure.

To address comments that site-specifically derived remediation goals would be inclusive of background rather than exclusive of background as shown here, additional risk analysis shows that addition of background concentrations to the remediation goals would not alter any judgments regarding the protectiveness of this approach.

7.3.7.2 Derivation of Chemical Remediation Criteria

As a point of departure, preliminary remedial goals were developed for the reasonable maximum exposure identified in the Feasibility Study (FS) which was more recently developed than the Baseline Risk Assessment. PRGs were calculated for both carcinogenic risk at a lifetime cancer risk of 1×10^{-6} (1/1,000,000) and for noncarcinogenic toxic effects at a hazard quotient (HQ) of 1.0 Under the NCP, PRGs may be modified based upon the consideration of appropriate factors including, but not limited to, exposure factors, uncertainty factors, technical factors and other factors consistent with the five balancing criteria to determine final remedial goals, so long as the remedy would still be protective.

Arsenic in surface soil was retained as a chemical of concern because some of the onsite soil samples contained levels of arsenic above background as well as above risk-based screening benchmarks. The carcinogenic point of departure PRG was 0.69 mg/kg and the noncarcinogenic PRG was 15.8 mg/kg. The carcinogenic point of departure of 0.69 mg/kg was considered unachievable. This concentration is an order of magnitude less than the average site background concentration of arsenic in surface soils (9 mg/kg). Cleaning up to 0.69 mg/kg is not achievable because many uncontaminated soils will contain more arsenic than this.

A final cleanup level of 60 mg/kg for arsenic in surface soil was determined based on considerations consistent with the five balancing criteria. This level is clearly distinguishable from background and the corresponding cancer risk of 9E-5 is within the protective risk range. Non-carcinogenic risk is also protective.

Cadmium in soil was retained as a chemical of concern because it was present onsite in concentrations above average site background (0.75 mg/kg), because some onsite concentrations exceeded risk-based screening levels, and because cadmium may have been present in some of the MED/AEC wastes.

Cadmium is not carcinogenic for oral or dermal exposures. The 10^{-6} inhalation pathway carcinogenic point of departure is reached at 5.4 mg/kg compared with an HQ = 1 concentration of

1.7 mg/kg. Consequently, 5.4 mg/kg is identified as the PRG for cadmium based on the more conservative value. This concentration was considered to be unachievable as it is within the range of measured background values. Therefore, the cadmium cleanup goal was adjusted to the concentration corresponding to a HQ of 1, yielding a revised surface soil cleanup level of 17 mg/kg which is also protective of cancer risk at 3.1E-6 which is well below 1E-4, the upper end of the NCP protective range. Using this value will assure that the residual soil concentrations of cadmium are well below 17 and that the residual combined cadmium and uranium concentrations will not exceed an HI of 1.0.

A similar rationale may be applied to metals in deep soil. Deep soil cleanup guidelines for arsenic, cadmium, and uranium are based on the anticipated continued industrial use of the site. For arsenic and cadmium, the deep-soil criteria were based on the construction worker who is exposed to deep soil as described in section 6.2. The non-carcinogenic effects of arsenic and cadmium presented greater threats than the carcinogenic effects to the construction worker. The deep-soil concentrations determined for a hazard index value equal to one were 2,760 and 430 mg/kg for arsenic and cadmium, respectively. Cleanup of uranium to 150 pCi/g will result in a non-carcinogenic HQ of less than 0.1. Therefore, addressing uranium as a radiological threat reduces the non-carcinogenic effects of uranium to negligible values. Since cadmium and arsenic do not affect the same organs, their respective cleanup criteria for deep soils were established separately and below the soil concentrations equivalent to HQs equal to one (i.e., 2,500 and 400 mg/kg for arsenic and cadmium, respectively).

8 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The following discussion presents the advantages and disadvantages of the alternatives described in the preceding section in a comparative fashion, based on specific evaluation criteria prescribed under CERCLA. This information is used to select a preferred alternative for remediation of the SLDS.

Each of the remedial alternatives is evaluated using the nine criteria specified in the NCP. The criteria are derived from CERCLA Section 121. The criteria are:

- overall protection of human health and the environment;
- compliance with ARARs;
- long-term effectiveness and permanence;
- short-term effectiveness;
- reduction of toxicity, mobility, or volume through treatment;
- implementability;
- cost;
- state or support agency acceptance; and
- community acceptance.

The first two criteria are threshold criteria which must be attained by the selected remedial action. The next five criteria are considered primary balancing criteria, which are considered together to identify significant tradeoffs and determine the optimal alternative among those having passed the threshold criteria. The final two criteria are modifying criteria which are evaluated following public comment on the RI/FS and Proposed Plan. Table 8-1 presents the evaluation of the remedial alternatives. Summaries of the comparative analysis are provided in this section.

8.1 THRESHOLD CRITERIA

Overall Protection of Human Health and the Environment. This criterion addresses whether an alternative provides adequate protection of human health and the environment, and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls. It also examines whether the alternative poses any unacceptable short-term or cross-media impacts.

Each of the alternatives except no-action (Alternative 1) is protective of human health and the environment. The degree of protection and permanence of the protectiveness is a function of whether and to what extent an alternative uses dedicated engineering containment, a removal strategy, or institutional control strategies. Alternative 1, with contaminated media left in place, is the least protective. Alternative 2, with contaminated media left in place, is more protective through the use of institutional controls and site maintenance. Alternative 3 confers more protection than Alternative 2 through consolidating the soils in a central location and reducing the opportunity for exposure. Alternative 4 confers more protection than Alternative 3 through removing the highest

Table 8-1. Summary of Comparative Analysis of Site-Wide Alternatives

Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/ Site Maintenance	Alternative 3 Consolidation and Capping	Alternative 4 Partial Excavation and Disposal	Alternative 5 Complete Excavation and Disposal	Alternative 6 -Selective Excavation and Disposal
Overall Protection						
• Human Health	Not Protective	Protective as long as proposed institutional controls are maintained	Similar to Alternative 2, but risk is less if institutional controls fail because contaminated area is consolidated.	Protective	Protective	Protective
• Ground water	Not Protective	Prevents consumption by land use restrictions, drilling restrictions, and monitoring	Similar to Alternative 2, but risk is less if institutional controls fail because contaminated area is consolidated.	Protective	Protective	Protective
• Environment	Not Protective	Protective	Protective	Protective	Protective	Protective
Compliance with ARARs						
	Not compliant for soils	Compliant as long as proposed institutional controls are maintained	Compliant; site-specific supplemental standards and institutional controls invoked for capped area. Backfill would need to pass hazardous characterization	Compliant; backfill would need to pass hazardous characterization	Compliant; backfill would need to pass hazardous characterization	Compliant; backfill would need to pass hazardous characterization
Long-term Effectiveness and Permanence						
• Magnitude of Remaining Risk	Same as BRA	Low as long as proposed institutional controls are maintained	Low as long as proposed institutional controls are maintained; lower than Alternative 2 if controls fail.	Low	Low	Low
• Adequacy of Controls	Existing site security would provide limited control over exposure	Adequate as long as proposed institutional controls are maintained	Good	Good	Excellent	Good

Table 8-1. Summary of Comparative Analysis of Site-Wide Alternatives (Cont'd)

Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/ Site Maintenance	Alternative 3 Consolidation and Capping	Alternative 4 Partial Excavation and Disposal	Alternative 5 Complete Excavation and Disposal	Alternative 6 -Selective Excavation and Disposal
• Reliability of Controls	Limited by need for security	Reliable for security as long as institutional controls are maintained	Reliable for security as long as institutional controls are maintained. Better than Alternative 2 because area to be controlled is consolidated.	Reliable	Reliable	Reliable
• Long Term Management	Long-term management plan; environmental monitoring; site security	Long-term management plan; environmental monitoring; site security	Long-term management plan; environmental monitoring; site security	Long-term management plan; environmental monitoring; site security; radiological restrictions may be reduced following remedy selection for inaccessible soils and buildings 25 and 101.	Long-term management plan environmental monitoring; site security; only necessary until remedy for inaccessible soils and buildings25 and 101 is selected.	Long-term management plan; environmental monitoring; site security; radiological restrictions may be reduced following selection of remedy for inaccessible soils and buildings 25 and 101.
• Irreversible and Irretrievable Commitment of Resources	Restricted land use	Restricted land use	Restricted land use at capped area; fill material; petroleum	Restricted land use at disposal facility; restricted to confined industrial use; fill material; petroleum	Restricted land use at disposal facility; fill material; petroleum	Restricted land use at disposal facility; restricted to confined industrial use; fill material; petroleum
Reduction of Contaminant (overall)						
• Volume	None	None	None, however, treatment retained as a conditional part of the remedy	Onsite volume reduced with offsite disposal options; however, treatment retained as a conditional part of the remedy.	Onsite volume eliminated with offsite disposal options; however, treatment retained as a conditional part of the remedy.	Onsite volume reduced due to offsite disposal; however, treatment retained as a conditional part of the remedy.
• Toxicity	None	None	None	None	None	None
• Mobility	None	None	Reduced by the cap component of disposal	Reduced by removal component	Eliminated by removal component	Reduced by removal component

Table 8-1. Summary of Comparative Analysis of Site-Wide Alternatives (Cont'd)

Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/ Site Maintenance	Alternative 3 Consolidation and Capping	Alternative 4 Partial Excavation and Disposal	Alternative 5 Complete Excavation and Disposal	Alternative 6 -Selective Excavation and Disposal
Short-term Effectiveness and Environmental Impacts						
• Protection of Community	No additional health effect	Protective with controls	Minimal short-term risk to community; protective with controls; long-term benefit	Minimal short-term risk to community; protective with controls; long-term benefit	Minimal short-term risk to community; protective with controls; long-term benefit	Minimal short-term risk to community; protective with controls; long-term benefit
• Protection of Workers	No additional health effect	Protective with controls	Short-term occupational risk to workers; protective with controls	Short-term occupational risk to workers; protective with controls	Short-term occupational risk to workers; protective with controls, which may be discontinued following removal of inaccessible soil.	Short-term, occupational risk to workers; protective with controls
• Environmental Impacts						
– Geology and Soils	Potential uncontrolled migration of contaminants	Potential uncontrolled migration of contaminants	Short-term soil disturbance during excavation; replacement of soil	Short-term soil disturbance during excavation; replacement of soil	Short-term soil disturbance during excavation; replacement of soil	Short-term, soil disturbance during excavation; replacement of soil
– Water Quality	No adverse effects beyond baseline conditions	No adverse effects beyond baseline conditions	Short-term minor impacts during excavation; short-term impact on surface water; long-term improvement in surface and ground water	Short-term minor impacts during excavation; short-term impact on surface water; long-term improvement in surface and ground water	Short-term minor impacts during excavation; short-term impact on surface water; long-term improvement in surface and ground water	Short-term minor impacts during excavation; short-term impact on surface water; long-term improvement in surface and ground water
– Biotic Resources						
Terrestrial biota	No adverse effect beyond baseline conditions	No adverse effect beyond baseline conditions	Temporary loss of habitat; long-term benefits due to removal of contaminant source; permanent loss of habitat for disposal location	Temporary loss of habitat; long-term benefits due to removal of contaminant source	Temporary loss of habitat; long-term benefits due to removal of contaminant source	Temporary loss of habitat; long-term benefits due to removal of contaminant source

Table 8-1. Summary of Comparative Analysis of Site-Wide Alternatives (Cont'd)

Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/ Site Maintenance	Alternative 3 Consolidation and Capping	Alternative 4 Partial Excavation and Disposal	Alternative 5 Complete Excavation and Disposal	Alternative 6 -Selective Excavation and Disposal
Aquatic biota	No adverse effect beyond baseline conditions	No adverse effect beyond baseline conditions	Minimal adverse effect during excavation	Minimal adverse effect during excavation	Minimal adverse effect during excavation	Minimal adverse effect during excavation
– Threatened and Endangered Species	No impact	No impact	No impact	No impact	No impact	No impact
– Wetlands	No wetlands present	No wetlands present	No wetlands present	No wetlands present	No wetlands present	No wetlands present
– Floodplains	No impact	No impact	Potential impact over long-term if levee fails	No impact over long-term	No impact over long-term	No impact over long term
– Air Quality	No impact	Improvement with radon controls	Short-term increase in fugitive dust associated with remediation activities; improvement with radon controls	Short-term increase in fugitive dust associated with remediation activities; improvement with radon controls	Short-term increase in fugitive dust associated with remediation activities; improvement with radon controls	Short-term increase in fugitive dust associated with remediation activities; improvement with radon controls
• Archeological, Cultural, and Historical Resources	No impact	No impact	No impact	No impact	No impact	No impact
• Land Use and Recreational/Aesthetic Resources	Land use continues but future reuse is limited	Land use continues but future reuse is restricted by institutional controls	Restricted land use for inaccessible soils and capped area; restrictions on ground-water use; unrestricted land use for remediated areas	Restricted land use; restrictions on ground-water use and land use	Restricted land and ground-water use for inaccessible soils; unrestricted land use for remediated areas	Restricted land use; reduced restrictions compared to Alternative 4 due to greater depth of excavation; restrictions on ground-water use

Table 8-1. Summary of Comparative Analysis of Site-Wide Alternatives (Cont'd)

Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/ Site Maintenance	Alternative 3 Consolidation and Capping	Alternative 4 Partial Excavation and Disposal	Alternative 5 Complete Excavation and Disposal	Alternative 6 -Selective Excavation and Disposal
• Socioeconomic and Institutional Issues						
– Community and Institutional Issues	Conflict with community. Inhibits land use.	Conflict with community. Inhibits land use.	Near term impact on community. Allows development outside of capped area. Impact on industrial properties.	Near term impact on community. Allows development to proceed. Impact on industrial properties.	Near term impact on community. Allows development to proceed. Impact on industrial properties until inaccessible soil remediated.	Near term impact on community. Allows development to proceed. Less impact on industrial properties than Alternative 4.
– Public Services	No impact on utilities. Low potential for impact on emergency response services.	No impact on utilities. Low potential for impact on emergency response services.	Low impact on utilities. Short-term potential impact on emergency response services.	Low impact on utilities. Short-term potential impact on emergency response services.	Low impact on utilities. Short-term potential impact on emergency response services.	Low impact on utilities. Short-term potential impact on emergency response services.
– Local Transportation Impacts	No impact	No impact	Minor local traffic volume increased and road deterioration during implementation	Moderate local traffic volume increased and road deterioration during implementation	Significant local traffic volume increased and road deterioration during implementation	Moderate local traffic volume increased and road deterioration during implementation
• Unavoidable Adverse Impacts	Potential risks to human health and the environment posed by site-related contaminants	All contaminants remain onsite requiring institutional controls	Potential short-term negative impact on surface water and air quality; short-term loss of habitats and animals; potential increase in noise annoyance, fugitive dust and traffic volume	Potential short-term negative impact on surface water and air quality; short-term loss of habitats and animals; potential increase in noise annoyance, fugitive dust and traffic volume	Potential short-term negative impact on surface water and air quality; short-term loss of habitats and animals; potential increase in noise annoyance, fugitive dust and traffic volume	Potential short-term negative impact on surface water and air quality; short-term loss of habitats and animals; potential increase in noise annoyance, fugitive dust and traffic volume
• Short-term Uses and Long-term Productivity	Short-term use remains; long-term productivity would decline with limited reuse of land	Short-term use remains; long-term productivity would decline with restricted reuse of land	Short-term use influenced by remedial activities; long-term productivity high for unrestricted areas; cap reduces long-term productivity by restricting future land use	Short-term use influenced by remedial activities; long-term productivity high for unrestricted areas; reduced long-term productivity by restricting future land	Short-term use influenced by remedial activities; long-term productivity high for unrestricted areas; restricted at disposal facility	Short-term use influenced by remedial activities; long-term productivity high for unrestricted areas; long-term productivity enhanced over Alternative 4

Table 8-1. Summary of Comparative Analysis of Site-Wide Alternatives (Cont'd)

Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls/ Site Maintenance	Alternative 3 Consolidation and Capping	Alternative 4 Partial Excavation and Disposal	Alternative 5 Complete Excavation and Disposal	Alternative 6 -Selective Excavation and Disposal
				use		
• Cumulative Impacts	None	None	Ongoing activities at Mallinckrodt Inc. in relation to inaccessible soils. Loss of use of capped area.	Ongoing activities at Mallinckrodt Inc. in relation to inaccessible soils	Ongoing activities at Mallinckrodt Inc. in relation to inaccessible soils	Ongoing activities at Mallinckrodt Inc. in relation to inaccessible soils
IMPLEMENTABILITY						
• Technical Feasibility	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible
• Administrative Feasibility	Feasible	Feasible but requiring institutional controls such as rezoning and land use restrictions	Feasible but requires institutional controls such as rezoning, land purchases, land use restrictions.	Feasible but requires institutional controls such as rezoning and land use restrictions.	Feasible but requires institutional controls until remedy for inaccessible soils is selected.	Feasible but requires institutional controls such as rezoning and land use restrictions.
• Monitoring	Long-term onsite monitoring	Long-term onsite monitoring	Long-term onsite monitoring	Long-term monitoring at disposal facility and at locations of inaccessible soils	Long-term monitoring at disposal facility and at locations of inaccessible soils	Long-term monitoring at disposal facility and at locations of inaccessible soils
COST						
• Total Cost	$22 million	$29 million	$100 million	$92 million	$140 million (overburden reused)	$114 million (overburden to off-site disposal)

risk soil from the site. Alternative 6 confers more protection than Alternative 4 by removing contamination at lower concentrations to a greater depth than Alternative 4. Alternative 5 confers the most protection by removing the most contaminated soil from the site.

Alternatives 4 and 6 rely on continued institutional controls to maintain protectiveness. Alternative 3 would require permanent institutional controls for the capped area. Environmental monitoring and institutional controls are used in all alternatives to achieve protectiveness for the inaccessible soil and buildings 25 and 101 pending the selection of a remedy for these soils and buildings.

The no-action alternative cannot be implemented at the SLDS because it would not achieve the threshold criteria of being protective of human health and the environment as required by the NCP. It is included in the FS to provide a baseline case. Alternative 2 would use institutional controls to achieve overall protection of human health and the environment from soil and ground-water contamination. Alternatives 3, 4, 5, and 6 would use engineered and institutional controls to achieve overall protection of human health and the environment from soil and ground-water contamination.

Under Alternative 5, accessible contaminated materials will be ultimately excavated and disposed, with the result that institutional controls could be removed in the remediated areas. Alternatives 2, 3, 4, 5, and 6 will reduce the long-term risks associated with existing MED/AEC contamination to protective levels.

The transportation of the SLDS waste long distances from the site involves risk of injuries and fatalities that are much greater than any radiological cancer incidence resulting from these activities. The risk to the worker and the public from a transportation accident involving serious injury or fatality increases from Alternative 3, 4, 6 to 5 due to increasing excavated contaminated soil volume and necessary backfill volume. As the haul distances increase, the risk also increases.

Alternatives 3, 4, 5, and 6 would reduce contaminant mobility by capping or encapsulation as a component of disposal. Capping or encapsulation would prevent infiltration of precipitation through contaminated materials. Furthermore, capping or encapsulation would eliminate contaminant migration by means of wind erosion or surface runoff, and would prevent human exposure to the waste. Alternatives 3, 4, 5, and 6 provide the greatest degree of protection from residual risk because contaminated materials identified as posing potentially unacceptable risks to human health and the environment are removed from the site and permanently isolated in an engineered disposal facility. All current potential exposure pathways are eliminated by these alternatives.

Alternative 1 does not control ground-water use. Alternative 2 restricts the use of ground water through use of institutional controls. Alternatives 3, 4, 5, and 6 remove the source of potential future ground-water contamination from above and below the water table. Alternative 2 is more effective than Alternative 1 in controlling access to contamination. Alternatives 3, 4, 5, and 6 are as effective as Alternative 2 in controlling access to ground-water contamination and are more effective than Alternatives 1 and 2 at minimizing potential for future ground-water contamination and are comparable to each other in this regard.

Compliance with ARARs. This criterion addresses whether an alternative will meet all ARARs of Federal and state environmental laws, or provide justification for invoking a waiver. CERCLA Section 121(d) identifies specific circumstances under which an ARAR may be waived. However, no waivers would be required for remedial action alternatives discussed herein, except for the no-action alternative.

Alternative 1 would not comply with ARARs, since radionuclide concentrations in readily accessible soil would continue to exceed guidelines. Alternative 2 would meet ARARs through implementation of institutional controls. Alternatives 3, 4, 5 and 6 would comply with ARARs. Supplemental standards are applicable when it can be demonstrated that remedial action would cause environmental harm that is excessive compared to health benefits, where remedial action would pose a clear and present risk of injury to workers, or where cleanup costs are unusually high and contamination left in place presents no significant exposure hazard. Thus, Alternatives 3, 4, 5, and 6 would achieve ARARs with institutional controls being maintained for inaccessible soils at the site until a remedy is selected. Ground-water restrictions under institutional controls would cease in areas where the source term was remediated once protection of human health and the environment is demonstrated by risk assessment. Accordingly, these alternatives would comply with relevant standards for restoration of radiologically contaminated sites. Tables 10-1 and 10-2 contain a listing of ARARs.

8.2 PRIMARY BALANCING CRITERIA

Long-term Effectiveness and Permanence. This criterion addresses the magnitude of residual risk remaining at the conclusion of remedial activities, and the adequacy and reliability of controls established by a remedial action alternative to maintain reliable protection of human health and the environment over time, once cleanup goals have been attained.

Alternative 5 has the highest degree of long-term effectiveness and permanence because contaminated soils are excavated for permanent disposal at permitted offsite facilities. Alternative 6 has the second highest degree of long-term effectiveness and permanence because the criteria used for excavation below 4 to 6 feet depth are higher than Alternative 5. Alternative 4 is third because the higher concentration criteria begins at a depth of 2 feet. Alternatives 4, 5 and 6 rely more on engineering controls and less on institutional controls for isolating contamination from the environment. Alternatives 3, 4, 5, and 6 have a high degree of long-term effectiveness and permanence compared to Alternatives 1 and 2 in terms of residual risk because contaminated soils are either permanently disposed of onsite or are transported offsite for permanent disposal. The cap for onsite disposal under Alternative 3 provides isolation of contamination from the environment. Alternatives 3, 4 and 6 rely more on institutional controls and less on engineering controls, therefore making these alternatives less effective in the long-term than Alternative 5. Alternative 2 has only a moderate degree of long-term effectiveness and permanence compared to Alternative 1 due to the contaminated soils and building materials remaining onsite and the primary use of institutional controls. Alternative 1, No Action, has low long-term effectiveness and permanence.

Pursuant to SARA, a long-term management plan would be implemented, including reviews every five years for all alternatives because some radioactive contaminants (ie, soil and/or ground water) would remain onsite. By using institutional controls and ground-water monitoring, Alternatives 2, 3, 4, 5 and 6 would achieve comparable long-term effectiveness and permanence for ground water.

Implementing Alternatives 2 or 3 would result in the permanent commitment of land for waste disposal. This commitment would occur throughout the SLDS for Alternative 2, and at Plant 2 or the City Property for Alternative 3.

The Alternative 3 onsite cap would cover most of the Plant 2 area. A portion of the perimeter would need to be used as a buffer zone and the sides of the cap would be sloped to promote drainage. No other area of the SLDS would sustain a long-term impact as a result of this cleanup action. Perpetual care would be needed for the committed land because the waste would retain its toxicity for thousands of years. Thus, the cap would need to be visually inspected, ground water would be monitored, and the effectiveness of the overall system would be reviewed every five years under Alternative 3.

Implementing any of the final action alternatives would not be constrained by the availability of resources or supplies beyond those currently available in the St. Louis area or expected to be available at the offsite disposal facilities. Consumptive use of geological resources (eg, quarried rock, sand, and gravel) and petroleum products (eg, diesel fuel and gasoline) would be required for the removal, construction, and disposal activities for Alternatives 3, 4, 5 and 6. Adequate supplies of these materials are readily available in the St. Louis area and would also be available in the area of the offsite disposal sites. Additional fuel use would result from offsite transport of the waste. However, adequate supplies are available without affecting local requirements for these products.

Reduction in Contaminant Volume, Toxicity, and Mobility through Treatment. This criterion addresses the statutory preference (CERCLA Section 121) for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as their principal element. This evaluation addresses the anticipated performance of the technologies that may be employed in achieving these treatment goals. It includes the amount of waste treated or destroyed; the reduction in toxicity, mobility, or volume; the irreversibility of the treatment process; and the type and quantity of residuals resulting from the treatment process.

At this time, treatment is a conditional component of all the retained remedial alternatives except Alternatives 1 and 2. Even though none of the alternatives offer reduction in contaminant volume, toxicity, or mobility through treatment, the addition of treatment (if warranted in the future) could be achieved as an adjunct to Alternatives 3, 4, 5 and 6.

Alternatives 3, 4, 5 and 6 would reduce contaminant mobility by disposal of the contaminated soils. The disposal of the soils under the cap in Alternative 3 would reduce the migration of contaminants by retarding infiltration into contaminated soil, by preventing fugitive dust emissions, and by isolating surface runoff from the contaminated media. Offsite disposal for Alternatives 4, 5 and 6 would reduce onsite contaminant volume because contaminated materials would be permanently disposed of offsite.

Short-Term Effectiveness. This criterion addresses the effects of an alternative during the construction and implementation phase until remedial action objectives are met, including the speed with which the remedy achieves protectiveness and the potential to create adverse impacts on human health and the environment during construction and implementation. Also included under this criterion are impacts to soil, water, biotic resources, air quality, socioeconomics, land-use, aesthetic/recreational resources, and cultural/historical resources.

An increase in the complexity of an alternative typically results in a decrease in short-term effectiveness because of increased waste handling and processing. Other than Alternative 1, Alternative 2 is the most effective in protecting the community and workers from short-term impacts and in achieving implementation because there is no handling nor removal of waste materials. Alternative 2 requires the shortest time to implement, followed by Alternative 3. Alternatives 4 and 6 would have significantly greater short-term impact than Alternatives 1, 2, or 3 because contaminated soils would be shipped offsite, constraining the excavation rate. Alternative 5 has the longest implementation time frame. Alternatives 2, 3, 4, 5 and 6 are comparable in short-term effectiveness of ground-water contamination control.

With respect to soil excavation, Alternative 3 has a higher degree of short-term effectiveness compared to the other excavation alternatives, because it requires the minimum amount of handling or movement of the contaminated soils among the action alternatives. Once the soils are removed and incorporated into the area to be capped, an initial layer of fill material is deposited on the contaminated materials. The initial layer of fill material would isolate the workers from the source material during remedial activities. Dust generated by the earth-moving aspects of the alternative would be controlled.

Alternatives 4, 5 and 6 offer a moderate degree of short-term effectiveness compared to Alternative 3 because they would require more time to implement than Alternative 3. The nonradiological occupational hazards increase significantly for Alternatives 4, 5, and 6. Fugitive dust generation and increased erosion and silt loading of surface waters are among the most significant concerns of Alternatives 4, 5 and 6.

Implementability. This criterion addresses the technical and administrative feasibility of implementing an alternative, and the availability of services and materials required during its implementation. This evaluation includes such items as the ability to construct and operate the technology; the reliability of the technology; the ease of undertaking additional remedial actions; the ability to obtain services, capacities, equipment, and personnel; the ability to monitor the performance and effectiveness of technologies; and the ability to obtain necessary approvals and coordinate with regulatory agencies and authorities.

The design, engineering, and administrative requirements of Alternatives 1 and 2 are essentially negligible. Materials required for the components of these alternatives are readily available. The remaining alternatives are technically and administratively feasible. The engineering, design, and administrative requirements increase with the complexity of the alternatives in the following order: 4, 5, 6 and 3. Alternative 3 has the greatest complexity because of the construction of the cap in addition to excavation. Except for Alternatives 1 and 2, Alternative 4 is the most amenable to timely implementation of an expedited remedial approach. It requires the least site preparation, provides disposal (without construction of a disposal facility) of a smaller volume than Alternative 5 or 6, and involves the fewest logistical problems. Alternative 5 is the next best approach to implementing expedited soil removal. It is less implementable than Alternative 4 because of the increased volume. Volumes of soil under each alternative are given in Table 8-2. Alternatives 4 and 6 would require segregating soil below deep-soil criteria and returning this material to depth. Alternative 3 would remove the same volume of soil as Alternative 5, but the additional task of design and construction of the liner and cap would delay implementation of Alternative 3 relative to Alternatives 4, 5 and 6.

Materials and services for the removal of contamination and environmental monitoring activities for the various alternatives are readily available. The degree of difficulty in implementing alternatives increases with the amount and depth of contaminated soils to be excavated, the level of the design/transportation required to dispose of soils in accordance with regulations, and the time/coordination involved in completing the alternative. The degree of difficulty greatly increases when the excavation proceeds below the water table. This is due to the excavation of saturated materials requiring dewatering prior to disposal.

Cost. The comparative analysis of costs examines the differences in capital, operations and maintenance (O&M), and present-worth values. Costs for each alternative, itemization of individual components, and the sensitivity analysis for each alternative can be found in Appendix B of the FS. The total costs for the alternatives increase as follows: Alternatives 1, 2, 4, 3, 6 and 5. The total 30-year costs for the six alternatives are:

- Alternative 1 – No Action $22 million
- Alternative 2 – Institution Controls and Site Maintenance $29 million
- Alternative 3 – Consolidation and Capping $100 million
- Alternative 4 – Partial Excavation and Disposal $92 million
- Alternative 5 – Complete Excavation and Disposal $140 million
- Alternative 6 – Selective Excavation and Disposal $114 million

The differences in costs among alternatives are very significant and increase primarily with the amount of contaminated soil to be excavated. Alternatives 2 and 4 do not include long-term costs for management of residual contamination which are eliminated by Alternative 5 and addressed more comprehensively by Alternative 6.

Table 8-2. St. Louis Downtown Site Volume

Volume	Alt. 1 No Action	Alt. 2 Institutional Controls and Site Maintenance	Alt. 3 Excavation, Consolidation & Capping	Alt. 4 Partial Excavation & Disposal	Alt. 5 Complete Excavation & Disposal	Alt. 6 Selective Excavation & Disposal
Impacted Volume Excavated (Insitu)	0	0	87,900	44,900	87,900	57,983
Overburden and Overexcavation Volume Excavated (Insitu)	0	0	71,986	24,259	71,986	42,822
Total Volume Excavated (Insitu) including impacted materials, overburden, and over-excavation (Insitu)	0	0	159,886	69,159	159,886	100,805
Volume of Below Criteria Excavated Material used as Backfill	0	0	54,406	15,279	54,406	17,601**
Disposal Volume prior to application of 1.25 swell factor	0	0	0*	53,880	105,480	83,204
Final Disposal Volume	0	0	0*	67,350	131,850	104,005

* Table shows accessible volumes only. Inaccessible soils will be disposed of as they become available in the future.

** Alternative 6 below criteria overburden is used only as deep soils backfill with the balance sent to disposal.

8.3 MODIFYING CRITERIA

State and Community Acceptance. This criterion evaluates the technical and administrative issues and concerns the State and neighboring communities may have regarding each of the alternatives.

The St. Louis Site Remediation Task Force requested that remediation at the St. Louis Downtown Site and the City Levee continue or begin with 'site specific' standards for industrial or recreational use, respectively."

A wide spectrum of stakeholders, including MDNR, local governments, federal agencies and lawmakers, citizen groups, and concerned citizens participated in the review of the proposed plan for SLDS during the 30-day comment period starting on April 8, 1998 and ending on May 8, 1998. A public meeting was held on April 21, 1998 to hear comments and answer questions regarding the SLDS' feasibility study and proposed plan.

State and public comments expressed concern over the protectiveness of Alternative 4 with respect to workers' health and the consequences of future liabilities Mallinckrodt, Inc. would have to negotiate as the result of handling and disposing of contaminated soils displaced during future construction and enhancement projects. Both state regulators and community stakeholders expressed overwhelming support for Alternative 6, particularly for the increased depth of remediation. It was asserted that the more extensive cleanup associated with Alternative 6 would not only provide greater protection of the worker, it would also allow Mallinckrodt the flexibility it needed to expand and grow, and be a valuable asset to the community without future remediation obstacles. Some support was also expressed for Alternative 5.

The Missouri Department of Natural Resources commented that:

> *"The State of Missouri prefers Alternative 6 as the remedy for cleaning up radioactive contamination at the St. Louis Downtown Site. We believe Selective Excavation and Disposal provides the best vehicle for attaining the objectives of the St. Louis Site Remediation Task Force. Only approved off-site borrow should be used to fill the excavations at the vicinity properties.*
>
> *We do believe the remediation should clean up to industrial use criteria the Mallinckrodt site and 5/15 'any use' levels at any depth for the vicinity properties. We believe Alternative 6 can be accomplished in a manner that will leave property owners whole. Such will result in the best response to the federal nuclear weapons production legacy in this part of the community."*

The community also expressed concern that Alternatives 4 and 6 did not address removal of all the contamination on Vicinity Properties to the stringent "composite" criteria, regardless of depth. The reviewers felt that the VP soils need to be remediated to levels which would allow for unrestricted land-use and soils that are inaccessible at the time of remediation should be managed with institutional controls until such time as the obstruction is removed. Once the obstruction is cleared the contaminated soil should be remediated.

Concerns were also expressed regarding contaminated soils remaining onsite under Alternative 3, which involved capping the soils. No State or public concerns were expressed regarding Alternatives 1 and 2. The Responsiveness Summary in Appendix A discusses and responds to individual comments received during the public meeting and throughout the comment period.

9 THE SELECTED REMEDY

EPA and the USACE have determined that Alternative 6 (Selective Excavation and Disposal) is the most appropriate remedy for this operable unit and ground water and accessible soil at SLDS based upon consideration of the requirements of CERCLA, the detailed analysis of the alternatives using the nine criteria, and extensive public participation and comment. This alternative, a refinement to Alternative 4, makes it unlikely that the federal government will have to manage and dispose of soil containing residual levels of radioactivity displaced by future industrial construction and maintenance projects at the SLDS. It also reduces the need for additional risk and fate and transport studies to demonstrate that the site remains protective.

Several areas of particularly elevated radioactivity exist within the OU, especially where uranium ore was digested and uranium was extracted. No treatment technology has been identified that could cost effectively reduce the mobility and toxicity of the radioactivity to acceptable risk levels, primarily because the toxicity of radionuclides cannot be reduced through treatment. Treatment is retained as a conditional part of the remedy. Treatment will be fully assessed during the design phase. If a treatment technology is identified to reduce the contaminant's volume, toxicity, or mobility and is demonstrated to be cost effective, it may be included as an adjunct to excavation. The volume and mobility of the contaminants are reduced without treatment by removing them and disposing offsite in an approved facility. The remedial action's excavation of soil also mitigates potential adverse health affects from the toxic and carcinogenic nature of the contaminants.

Approximately 77,000 m^3 (100,000 yd^3) of soil will be excavated under this remedy. This includes the excavation of overburden that must be removed in order to access subsurface pockets of contamination. Approximately 13,000 m^3 (17,000 yd^3) of this soil will be returned to depths below 1.2 or 1.8 m (4 or 6 ft) as backfill, because it does not exceed the deep-soil criteria (risk-based) or exhibit a hazardous characteristic. The remainder of excavated soil will be disposed offsite. Approved borrow obtained from an offsite location will be used to backfill excavations above 1.2 or 1.8 m (4 or 6 ft) to grade. [The estimated cost for the remedy for this operable unit is $114 million.]

Sources of soil contamination within the A Unit's ground water will be removed and water that must be managed as part of the excavation will be treated and disposed of appropriately. Ground water in the B Unit is not currently impacted by COCs identified in this remedy.

The goal of the ground-water portion of this remedy is to maintain protection of the potentially usable ground water (B unit) and establish the effectiveness of the source removal action in this regard. The strategy to accomplish this goal is to install and monitor perimeter wells on a long-term basis to demonstrate that there will be no significant impacts from COCs on the Mississippi Alluvial Aquifer (B Unit). Monitoring will be conducted during and after the source-term removal. If monitoring of the B Unit shows that the MED/AEC COCs have significantly exceeded MCLs or thresholds established in 40 CFR 192, a Ground-water Remedial Action Alternative Assessment (GRAAA) would be initiated. The GRAAA would model and resolve:

MED/AEC COC fate and transport, risk to the public and environment, practical and efficient technologies to reduce the COCs, the likely concentration to be removed, the likely concentration of the COC(s) remaining post-treatment, impact of Mississippi River flooding inflows to the B Unit, and a recommendation for action in the Mississippi Alluvial Aquifer, the B Unit. The outcome of the alternative assessment could lead to an action for ground-water improvement within the Mississippi Alluvial Aquifer. Regardless of whether the GRAAA is implemented, a ground-water monitoring plan will be developed as part of the remedial design to evaluate the impacts of the Remedial Action. The goal of the monitoring plan will be to assess the fate and transport of MED/AEC residual contaminants through and following the Remedial Action. A monitoring program for ground water will be established and enforced until discontinued pursuant to five year CERCLA review.

The estimated cost of this remedy is $114 million.

Cleanup levels

The purpose of this response action is to control risks posed by direct contact with soils and sediments and to maintain low concentrations of MED/AEC COCs in the B Unit's ground water. (The State of Missouri has designated the B Unit as a potential future public drinking water supply). The baseline risk established for this site indicates that existing conditions in this operable unit potentially pose an excess lifetime cancer risk to a commercial/industrial worker of 5×10^{-3} from direct contact with soil and sediments. There is not a plausible future pathway for ingestion of currently impacted ground water under the reasonable projected industrial land use, nor do COCs related to this operable unit currently exist at significant concentrations in the B Unit. The investigative limits when exceeded trigger the GRAAA are: 50 µg/L for arsenic, 5 µg/L for cadmium, or 20 µg/L for total uranium.

This remedy will address soil contaminated with radioactivity, arsenic, and cadmium related to MED/AEC uranium manufacturing and processing at SLDS. Contaminants mixed or commingled with these MED/AEC radiological COCs will be removed as a consequence of the remedial action to address these MED/AEC COCs.

Post-remedial risks for this remedy are presented in Table 9-1 for a commercial/industrial worker and for a construction worker. These scenarios represent the most likely future land use scenario: that SLDS will remain an industrial facility under institutional control. Risk estimates were calculated for the FS and are summarized here assuming that the preferred alternative (Alternative 6) has been implemented.

The commercial/industrial worker represents a full-time on-site worker that occasionally excavates into shallow site soils. This worker could be exposed to residual concentrations of radionuclides that remain under several feet of approved borrow (used as backfill after remedial actions) or soil near or at the surface that meet the criteria in 40 CFR 192. The construction worker is an individual that receives a one time exposure to deep materials. This worker could potentially be exposed to soil excavated to the 50/100/150 pCi/g criteria or to soil remediated to 40 CFR 192 criteria.

Table 9-1. Residual Risk at SLDS

Residual Risk for Radionuclides by Exposure Scenario					
Analyte [a]	Primary Pathway [b]	Commercial/Industrial [c]		Construction [c]	
		> 2-ft Cover	5/15 pCi/g	5/15 pCi/g	50/100/150 pCi/g
Ac-227	Inhalation	$< 10^{-6}$	$1x10^{-5}$	$< 10^{-6}$	$< 10^{-6}$
Pa-231	Inhalation	$< 10^{-6}$	$7x10^{-7}$	$< 10^{-6}$	$< 10^{-6}$
Ra-226	External gamma	$< 10^{-6}$	$2x10^{-4}$	$4x10^{-6}$	$4x10^{-6}$
Th-230	Inhalation	$< 10^{-6}$	$7x10^{-7}$	$< 10^{-6}$	$3x10^{-6}$
Th-232	External gamma	$< 10^{-6}$	$1x10^{-4}$	$2x10^{-6}$	$4x10^{-6}$
U-238	Inhalation	$< 10^{-6}$	$8x10^{-6}$	$< 10^{-6}$	$1x10^{-6}$
Total Risk from Radionuclides		$< 10^{-6}$	$3x10^{-4}$	$6x10^{-6}$	$1x10^{-5}$
Residual Risk and Hazard Index for Non-Radionuclides by Exposure Scenario [d]					
Arsenic	n/a [e]	n/a	n/a	n/a	n/a
Cadmium	n/a	n/a	n/a	n/a	n/a
Uranium	n/a	n/a	n/a	n/a	n/a

[a] Includes relevant decay products and associated radionuclides. That is, Pb-210 is include with Ra-226; Ra-228 and Th-228 are included with Th-232; and U-234 and U-235 are included with U-238.
[b] Pathway resulting in largest contribution to risk is listed. Pathways include direct gamma, soil ingestion, and dust inhalation.
[c] From the St. Louis Downtown Site Feasibility Study (USACE 1998). Six exposure units are evaluated in the Feasibility Study. The highest (most conservative) risk from those exposure units is listed. Because the selected alternative calls for the removal of soil to 4-6 ft depths with approved borrow used as backfill, the risks for assuming cover are presented. The residual risk for remediation to 5/15 pCi/g with no cover is also presented for comparison. A thicker cover (e.g., 4-6 ft) would result in reduced risk. It is assumed that the construction worker digs through any clean cover and could dig into deep materials that were remediated to the 50/100/150 pCi/g criterion.
[d] Because there is insufficient data to support reasonable assessment of risk from exposure to all MED/AEC related chemical, post-remedial risk and hazard index estimates are not provided. Prior to completion of remedial activities, sufficient new data will be collected to support post-remedial risk estimates including these chemicals.
[e] not applicable

All risk estimates are rounded to one significant digit. Reported values may contain round-off error.

Table 9-1 lists the risks subsequent to implementation of the selected remedy to potential receptors from the primary radiological MED/AEC related COCs including Ac-227, Pa-231, Ra-226, Th-230, Th-232, and U-238. Exposure pathways considered include direct gamma, soil ingestion, and dust inhalation. The pathway that resulted in the highest relative risk for each radionuclide is also listed.

Six exposure units were evaluated for OU. The two exposure units with the highest residual risk from radioactivity of 3×10^{-4} excess cancer incidents is reported in Table 9-1. These values correspond to the scenario for a commercial/industrial worker with the assumption that no protective cover is provided. The residual risk for the remaining 4 exposure units, using the same exposure assumptions, ranged between 1.8×10^{-4} and 2.7×10^{-4}. Since assumptions used to calculate residual risk are much more conservative than conditions required for remediation (no cover assumed as opposed to 4-5 feet depth of off-site borrow required), actual site risk would be lower than the calculated values.

A key component of this remedy, recommended by the community and other stakeholders, is that approved offsite borrow is to be used to backfill the excavations from grade to 1.2 or 1.8 m (4 or 6 ft). Greater use of offsite borrow and extending the depth of the composite criteria are the significant differences between Alternative 4 and the selected remedy. Alternative 6 was selected as the remedy primarily because it reduced the liability of the federal government from costs associated with managing and disposing of soil containing residual radioactivity displaced by future construction or maintenance projects. The use of this thickness of approved offsite borrow also has the benefit of reducing the post remedial risk to well below the 1×10^{-6} level for excess cancer incidences for the commercial/industrial worker. On the rare occasion that a construction worker works at depths greater than 1.2 or 1.8 m (4 or 6 ft), the excess lifetime cancer incidence risk of that worker would not exceed 1×10^{-5} for the highest risk exposure unit.

Insufficient data was available in some of the exposure units to support a reasonable assessment of risk from the chemical contaminants. The excess cancer incidence from arsenic will be reduced to 9×10^{-5} and cadmium will not exceed a hazard index of approximately 0.9 if it is assumed that the average concentration of arsenic and cadmium will simply meet the criteria established for this cleanup. The actual average concentrations remaining after excavation will be far below these values considering that 1.2 or 1.8 m (4 or 6 ft) of approved offsite borrow will be used to backfill the excavations.

Note that the exposure scenarios considered in this evaluation represent reasonable maximum exposure conditions that tend to overestimate actual risk.

The cleanup criteria for this operable unit apply to areas affected by the MED/AEC uranium manufacturing and processing activities and consist of the following components:

- Excavation of accessible soils according to the ARAR-based composite cleanup criteria of 5/15 pCi/g above background for Ra-226, Ra-228, Th-232, and Th-230, and 50 pCi/g above background for U-238 in the uppermost 1.2 or 1.8 m (4 or 6 ft) throughout the OU and at the Perimeter VPs (see section 1.1). See Section 10 for ARAR determination.

- On the portion of the Mallinckrodt property addressed in the OU, site-specific target removal levels of 50 pCi/g above background for Ra-226, 100 pCi/g above background for Th-230, and 150 pCi/g above background for U-238 (50-100-150 guidelines) will be used as the deep-soil cleanup guidelines below 1.2 m (4 ft) in most areas within the plant boundaries and below 1.8 m (6 ft) as described in Section 7.3.6.

- For arsenic and cadmium:

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

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

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

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

- A post-remedial action risk assessment will be performed to describe the level of risk remaining from MED/AEC contaminants following completion of remedial activities;

- Final determinations as to whether institutional controls and use restrictions are necessary will be based on calculations of post remedial action risk derived from actual residual conditions. Five year reviews will be conducted per the NCP for residual conditions that are unsuitable for unrestricted use.

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

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

- Perimeter wells in the Mississippi Alluvial Aquifer will be monitored to determine if further action will be required with respect to ground water,

- Protactinium-231 (Pa-231) and actinium-227 (Ac-227) will be included in the analyses for the post-remedial action residual site risk; and

- Contaminated sediments in sewers and drains considered to be accessible will be remediated along with the soils.

During the remedial investigation of the SLDS, sediments containing radioactivity were found in a small area of the Mississippi River bed. A subsequent investigation could not re-locate radioactivity on the river bed. Presumably it was carried downstream during high flows. The location of the river bed where radiological contamination was detected during the remedial investigation will be revisited and characterized. If radiological contamination criteria established in this ROD are exceeded, the remediation of the river bed will be addressed under a subsequent response action . If no contamination is present above the composite criteria (ARAR based), the remedy will be considered the final remedy for this portion of the site.

Contamination present beneath the existing levee will be addressed in a subsequent response action. The exposure and land-use assumptions used to remediate the bicycle trail on the strip of land east of the levee and west of the Mississippi River, were different than the assumptions used in this ROD. The area standards, as part of interim actions preceding this ROD, were established after discussions with the St. Louis Site Remediation Task Force. No further action is necessary for this property, but it is to be included in the post remedial action risk assessment for the OU to determine whether restrictions will be required on this portion of the site.

No further action is required on City Block 1201 except to include it in the post-remedial action risk assessment to reconfirm the protectiveness of the removal action there.

Alternative 6 is selected as the preferred remedy for the SLDS. It is protective of human health and the environment, meets ARARs, and was developed to provide the best balance of effectiveness, cost, and implementability compared with the other alternatives considered. Additionally, it addresses more fully the CERCLA modifying criteria of “state and community acceptance.”

All the proposed alternatives are protective of human health and the environment. Alternative 6 provides more protection than any of the others except for Alternative 5. Alternative 6 removes the contaminated soil to at least the 1.2 or 1.8 m (4 or 6 ft) depth. This depth is needed for protection of industrial workers during ongoing operations. Only Alternatives 3 and 5 remove deeper soil from the contaminated locations, however Alternative 3 consolidates the excavated material under an earthen cap located onsite. This cap would require maintenance and institutional controls to be effective.

Alternative 6 would comply with applicable and relevant requirements for permissible levels of residual contamination through a combination of excavation of the contaminated soil above the human health target risk range, removal of soil above 40 CFR Part 192 requirements within the depth of plausible intrusion, and institutional controls. Public doses would be less than 25 mrem/yr as required by 10 CFR 20 Subpart E. Residual risk would be within the CERCLA target risk range. Institutional controls would ensure continued protectiveness through digging restrictions and adherence to federal and state worker safety regulations. Alternative 6 could readily be performed in accordance with specific ARARs.

The remedial action taken under Alternative 6 would provide a permanent and effective means of protecting the workers and the public from the residual MED/AEC contaminants in the soil. The alternative would permanently remove the significant contaminants in the upper 1.2 or 1.8 m (4 or 6 ft) of soil at the site. In addition to removal of contaminated soil, backfilling with 1.2 or 1.8 m (4 or 6 ft) of approved borrow will make exposure to the remaining contaminants unlikely. The backfill will also shield potential receptors from gamma emissions. Exposure to the material left below the 1.2 or 1.8 m (4 or 6 ft) boundary, as well as the contaminated soils that are inaccessible, would be managed by implementing institutional controls and a monitoring program.

Alternative 6 is readily implementable, as are all the alternatives evaluated. The components of the remedial action use well established site preparation, excavation, and disposal strategies used at other commercial and CERCLA sites. The occupational and radiological hazards associated with implementing the remedial action are easily mitigated through the use of protective equipment and the adherence to OSHA regulations and the approved health and safety plan. The institutional controls and monitoring programs can be implemented fairly quickly. The materials, as well as experienced labor resources needed to perform the remedy, are abundantly available. The necessary permits and municipal approvals are also obtainable with few delays. The overall time to implement Alternative 6 is not significantly different from the other excavation alternatives.

The cost of Alternative 6 is lower than Alternative 5, the most protective alternative. Although the cost for the rest of the alternatives are less than 6, they are not as effective in permanently protecting the current or future land-user. Alternative 3 is only effective as long as the cap is maintained and institutional controls are enforced. Alternative 4 would leave material exceeding free release criteria at depths below 0.6 m (2 ft) where it may be inadvertently disturbed during ordinary renovation and construction activities. In addition to increased risk and dose to the worker, such intrusions would result in unaccountable future liabilities for waste handling and disposal. Although Alternative 5 provides the most permanent and most effective protection of human health and environment, it is not cost effective. The cost benefit trade-off of complete removal to all depths, as in Alternative 5, is high since only the top 1.2 or 1.8 m (4 or 6 ft) of the soil has the potential for significant human exposure during the industrial life of the site. Alternative 6 would cost $22 million more than Alternative 4, but the reduction in dose, risk, and future liability would be substantial. In addition, implementation of Alternative 6 would reduce the probability of material being brought to the surface where it would impose an increased risk. Alternative 6 was the preferred remedy of the State of Missouri, Mallinckrodt, and the public though it provides protectiveness exceeding CERCLA requirements.

Based on the above discussions, Alternative 6 is believed to provide the best balance among the six alternatives with respect to the NCP evaluation criteria. Alternative 6 is protective of human health and the environment, compliant with ARARs, implementable, low risk and cost-effective.

10 STATUTORY DETERMINATIONS

Section 121 of CERCLA requires that all remedial actions shall:

- be protective of human health and the environment
- attain legally applicable or relevant and appropriate standards, requirements, criteria, or limitations, unless such standard, requirement, criteria, or limitation is waived in accordance with Section 121(d)(4);
- be cost effective; and
- use permanent solutions and alternative treatment technologies to the maximum extent practicable.

The manner in which the selected remedy satisfies each of these requirements is discussed in the following sections.

10.1 PROTECTION OF HUMAN HEALTH AND ENVIRONMENT

Section 121(d)(1) of CERCLA requires remedial actions to attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further release that, at a minimum, assures protection of human health and the environment. The selected remedy for this operable unit at the SLDS will protect human health by reducing current and reasonably anticipated future risks to levels at or below CERCLA acceptable risk criteria. During remedial activities, institutional controls (e.g., access restrictions) and environmental monitoring and surveillance activities will be maintained to ensure protectiveness, so that no member of the public will receive radiation doses above guidelines from exposure to residual radioactive contaminants.

There are no short-term threats associated with the selected remedy that cannot be readily controlled and mitigated. In addition, no adverse cross-media impacts are expected from the remedy.

10.2 ATTAINMENT OF ARARS

Section 121(d)(1) of CERCLA requires that with respect to any hazardous substance, pollutant or contaminant that will remain onsite, remedial actions must, upon completion, achieve a level or standard of control which at least attains legally applicable or relevant and appropriate standards, requirements, criteria, or limitations under Federal environmental law or any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation (applicable or relevant and appropriate requirements or ARARs), unless such standard, requirement, criteria, or limitation is waived in accordance with Section 121(d)(4). Applicable requirements are those requirements which specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at the site.

Relevant and appropriate requirements are those requirements which, while not applicable to a release, are relevant and appropriate to the circumstances of the release. Section 300.400(g)(2) of the NCP lists various factors to be considered in determining whether a requirement is relevant and appropriate. These factors include the purpose of the requirement compared to the purpose of the CERCLA action, the medium regulated or affected by the requirement compared to the medium contaminated or affected at the site, and the substances regulated compared to the substances found at the site.

ARARs have been classified into three types to simplify identification and compliance with environmental requirements: action-specific requirements, chemical-specific requirements, and location-specific requirements. Action-specific requirements are those with which design, performance, and other aspects of implementation of specific remedial activities must comply. Chemical-specific requirements are media-specific and health-based concentration limits (criteria) developed for site-specific levels of contaminants in specific media. Location-specific standards are based on the particular characteristics or locations of the site, such as the presence of wetlands, floodplains, or sensitive ecosystems or habitats, or places of historical or archaeological significance.

In addition to ARARs, other advisories, criteria, or guidance may be useful in developing CERCLA remedies. These "to be considered" (TBC) advisories, criteria, or guidance may be developed by EPA, other federal agencies or states. The TBCs are not ARARs and are not legally binding. Their use is at the discretion of the lead agency if they would be useful to implementation of the selected remedy.

USACE has determined that the following statute and regulations are ARARs, as that term is defined in CERCLA, for the cleanup of the contamination present at the SLDS. All Federal laws and regulations pertaining to NEPA are not included as ARARs as the USACE is following the CERCLA process which is the functional equivalent to NEPA.

Chemical Specific ARARs

The USACE identified no requirements directly applicable to the cleanup of MED/AEC-related radiological contaminants in accessible soils at the SLDS. Regulations promulgated pursuant to the Uranium Mill Tailings Radiation Control Act (UMTRCA) at 40 C.F.R. Part 192 Subpart B apply to the cleanup of land and buildings with residual radioactive materials at designated inactive uranium processing sites. Since the SLDS is not one of the designated processing sites, these regulations do not apply to the SLDS. However, based upon comparisons of the purpose of these regulations with the purpose of this operable unit, the medium involved, and the hazardous substances regulated, the USACE concludes the standards found in 40 C.F.R. § 192.12(a) for cleanup of radium-226 in soils are relevant and appropriate to the cleanup of (radium-226) accessible soils at the SLDS. The areas of the SLDS adjacent to the portions of the site where uranium ores were digested are similar to vicinity properties of mill tailings sites with respect to the general distribution of contamination and the mechanism(s) which resulted in distribution of the contamination. Radium-226 and uranium are the major contaminants under Plants 7 and 2, respectively. Adjacent areas are similar to mill site vicinity properties in their proximity to uranium processing operations and associated migration of contamination from the uranium processing areas.

40 C.F.R. § 192.12(a) establishes cleanup standards for land, defined as "any surface or subsurface land that is not part of a disposal site and is not covered by an occupiable building. It provides that remedial actions shall be conducted so as to provide a reasonable assurance that the concentration of radium-226 in land averaged over any area of 100 square meters (m^2) shall not exceed the background level by more than 5 pCi/g averaged over the first 15 cm of soil below the surface and 15 pCi/g averaged over 15 cm thick layers of soil more than 15 cm below the surface.

In accordance with OSWER directive 9200.4-18 "Establishment of Cleanup levels for CERCLA Sites with Radioactive Contamination," the 5/15 pCi/g criteria for residual radium in soil are considered relevant and appropriate for SLDS. This site is sufficiently similar to Title I Sites under UMTRCA for the reasons stated above and in consideration of contaminant distribution. There is not a significant profile of contamination between 5 and 30 pCi/g in the subsurface and application of the 15 pCi/g subsurface criterion has resulted in a cleanup below 5 pCi/g. Site characterization data and general experience in excavation of these materials under previous removal actions, e.g., Plant 10, verify this result. Remediation of Plant 10 to the 15 pCi/g UMTRCA limit resulted in residual contamination below the 5 pCi/g. Similarity of the adjacent areas to mill site VPs when taken with the existing Plant 10 data (which achieved sub 5 pCi/g post remedial action soil concentrations for radium and thorium) supports the conclusion that UMTRCA VP criteria apply and that remediation to a design soil criteria of 15 pCi/g should assure protectiveness of the residual site.

40 C.F.R. § 192.21 provides for the establishment of supplemental standards in lieu of the standards in 40 C.F.R. § 192.12(a) under certain conditions. 40 C.F.R. § 192.21(c) provides for such supplemental standards when the estimated cost of cleaning up a vicinity site is unreasonably high in comparison to the long-term benefits, and the residual radioactive materials do not pose a clear present or future hazard. Remedial action is generally not necessary where residual radioactive materials have been placed semi-permanently in a location where site-specific factors limit their hazard and from which they are costly or difficult to remove, or where only minor quantities of residual radioactive materials are involved. Based on site-specific conditions at the SLDS, MED/AEC- related radiologically contaminated soils beneath 4 or 6 feet, depending upon the specific location on the Mallinckrodt property, satisfy the criteria for establishment of supplemental standards. Risk-based supplemental standards were developed as described in section 7.3.7.

40 C.F.R. § 192.02(a) provides that control of residual radioactive materials and constituents shall be designed to provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not exceed an average release rate of 20 pCi/m^2/second or increase the annual average concentration of radon-222 in the air at or above any location outside the disposal site by more than one-half pCi/l. These requirements are considered to be relevant and appropriate to cleanup of accessible soils at the SLDS.

Radon standards in Subpart B require that, in any occupied or habitable building, the objective of remedial action shall be to achieve an annual average radon decay product concentration (including background) not to exceed 0.02 working level. The remedy will satisfy this requirement for the units that are remediated. 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.

10 C.F.R. 20 Subpart E pertains to the decommissioning of NRC licensed facilities. It provides standards for determining the extent to which lands must be remediated before decommissioning of a site can be considered complete and the license terminated. These standards are: unrestricted use - 25 mrem/yr total effective dose equivalent (TEDE) and ALARA; restricted use - 25 mrem/yr TEDE 100 mrem/yr with loss of site controls and ALARA. These standards are applicable to any NRC-licensed materials commingled with MED/AEC-related wastes subject to this remedial action and are relevant and appropriate to any FUSRAP materials similar to licensable materials under the Atomic Energy Act.

Federal and state laws and regulations related to drinking water are not considered to be applicable or relevant and appropriate to currently impacted groundwater in Unit A beneath the SLDS. For the reasons summarized in Section 1.2.4, Unit A is not considered a potential source of drinking water. Use of the Mississippi River alluvial aquifer (Unit B) in this area is not likely; however, MCLs and the groundwater protection requirements found in 40 CFR Part 192, Subpart A, Table 1, are relevant and appropriate with regard to evaluation of the need for further study of groundwater in Unit B.

Action-Specific ARARs

UMTRCA, 42 U.S.C. 7901 et. seq., requires the control of residual radioactive material at processing and disposal sites in a safe and environmentally sound manner. This requirement is considered relevant and appropriate to the remedial action at the SLDS. The selected remedial action will provide for the removal of radiological contaminants to a level that protects the public health and the environment which meets this requirement.

Federal and solid and hazardous waste disposal laws and regulations are considered relevant and appropriate to any excavated materials that will be reused as fill materials on the site. A determination will be made as to whether excavated materials are a listed or characteristic RCRA hazardous waste before the excavated materials are used as onsite fill. The substantive requirements of the laws and regulations will be met for materials remaining at the site. State regulations regarding the disposal of radioactive materials in sanitary landfills are not considered to be applicable or relevant and appropriate.

State regulations pertaining to any state permits for onsite work, are not considered to be applicable or relevant and appropriate as CERCLA provides in Section 121 (e)(1), 42 U.S.C. 9621 (e)(1), that no federal, state, or local permits are required for the conduct of onsite response actions. Substantive requirements of such provisions will be implemented as appropriate.

Federal and State laws and regulations pertaining to Dredge or Fill requirements are not considered to be applicable or relevant and appropriate because no dredge or fill will be discharged into or removed from a wetland and/or waters of the United States as part of the remedial action.

Federal and State laws and regulations relating to drinking water are not considered ARARs because none of the A unit ground water is currently valuable as a drinking water source. Monitoring and assessment of the B unit ground water is addressed by the 40 CFR Subpart A, Table 1, as an ARAR.

State regulations pertaining to asbestos are not considered to be applicable or relevant and appropriate because the response action does not include the removal of buildings.

While Federal and State laws and regulations pertaining to Safety and Health Standards including, but not limited to OSHA, are not considered ARARs, per se, however, federal contractors are required to comply with applicable Safety and Health laws and regulations.

Location-Specific ARARs

Federal and State laws and regulations pertaining to the National Historic Preservation Act, State Historic Preservation Act, Archeological and Historical Preservation Act, and Native American Graves Protection and Repatriation Act are not considered to be applicable or relevant and appropriate.

Federal and state laws and regulations and Executive Orders pertaining to Floodplain Management and Protection are not considered to be applicable or relevant and appropriate because the site is not located on a floodplain, as defined by relevant regulations, 40 C.F.R. Part 6, Appendix A. The existence of a 500 year flood protection structure (the St. Louis floodwall) takes the SLDS out of the definition of a floodplain.

All Federal and State laws and regulations pertaining to Endangered Species are not included as ARARs in so far as available data indicates that there are no known endangered species or their habitats on the site.

Table 10-1 summarizes the chemical-specific ARARs appropriate for cleanup actions at the site. Table 10-2 summarizes the action-specific ARARs.

Table 10-1. Chemical Specific ARARS for the SLDS

Standard, Requirement, Criteria or Limitation	Citation	Description of Requirement	ARAR Status	Comment
Uranium Mill Tailings Radiation Control Act (UMTRCA) (October 1992): Cleanup of Radioactively Contaminated Land and Contaminated Buildings	40 C.F.R.192.12(a)	Residual radioactive material concentration of Ra-226 and Ra-228 in land averaged over any 100 m^2 area shall not exceed the background level by >5 pCi/g averaged over the first 15 cm of soil (6 inches) and 15 pCi/g averaged over 15 cm thick layers of soil >15 cm below the surface.	Relevant and Appropriate	This ARAR was used for to establish composite cleanup criteria for radium and thorium soils to a depth of 4-6 ft.
	40 C.F.R. 192.21 and 192.22	Supplemental Standards: Site-specific target removal levels of 50 pCi/g above background for Ra-226, 100 pCi/g above background for Th-230, and 150 pCi/g above background for U-238 (50-100-150 guidelines) will be used as the deep-soil cleanup guidelines below 1.2 m (4 ft) in most areas within the plant boundaries and below 1.8 m (6 ft) in areas delineated in Section 7.4.6.	Relevant and Appropriate	The provision allowing the development of supplemental standards under certain conditions was basis developing deep soil, i.e., greater than 4-6 ft., criteria.
	40 C.F.R. 192.02(b)(1)	Radon-222 releases not exceeding 20 pCi/m^3/sec. or 0.5 pCi/l in air above site	Relevant and Appropriate	
EPA Policy directives for radioactive contamination	OSWER Directive 9200.4-23	EPA policy for ARAR determination for radioactive sites.	TBC	These directives were consulted in developing radioactive cleanup criteria because of the similarly between these sites and the UMTRCA sites.
	OSWER Directive 9200.4-18	EPA policy on using 40 C.F.R. Part 192 for CERCLA cleanup criteria at radioactive sites, including radium and thorium.	TBC	
Uranium Mill Tailings Radiation Control Act	40 C.F.R. 192.40, 192.41	Criteria for sites where thorium ores were processed.	Relevant and Appropriate	This regulation was used in developing the thorium cleanup criteria.
Resource Conservation and Recovery Act	40 C.F.R. 257-272	Establishes accountability in handling hazardous waste from generation to disposal.	Relevant and Appropriate	Any excavated materials that remain on site will meet all hazardous waste requirements in addition to the radiological cleanup criteria.
NRC Radiological Criteria for License Termination	10 C.F.R. 20 Subpart E	This rule provides consistent standards to NRC licensees for determining the extent to which lands must be remediated before decommissioning of a site can be considered complete and the license terminated.	Applicable	These criteria would be applicable to any NRC-licensed materials commingled with MED/AEC-related wastes and are relevant and appropriate to materials similar to Atomic Energy Act licensable materials.

Table 10-2. Action Specific ARARS for the SLDS

Standard, Requirement, Criteria or Limitation	Citation	Description of Requirement	ARAR Status	Comment
General Pretreatment Regulation	10 CSR 20-6.100	Provides for procedures to prevent the introduction of pollutants into publicity-owned treatment works (POTWs).	Applicable	To the extent waters are encountered during cleanup, and disposal to a POTW is chosen, pretreatment requirements will be met.
Solid Waste Disposal Act, as amended; Identification and Listing of Hazardous Wastes	40 C.F.R. 260 and 261	Provides for identification and characterization of hazardous wastes.	Relevant and Appropriate	These requirements will be used only for purposes of analyzing suitability of excavated material for backfill onsite.
RCRA Land Disposal Restrictions	40 C.F.R. 268	Provides rule for treatment hazardous waste before landfilling.	Relevant and Appropriate	These are applicable only for purposes of analyzing suitability of excavated material for offsite disposal and for analyzing for backfill onsite.
Clean Water Act, National Pollutant Discharge Elimination System; Water Quality Standards	40 C.F.R. 122-125 10 CSR 20-7.031 (4) (I)	Provide for limitations on point source discharge to surface water.	Relevant and Appropriate	If a point source discharge is sued to dispose of waters encountered during cleanup, specific effluent limits will be established as part of work plans developed during remedial design or remedial action. However, a formal NPDES discharge permit will not be obtained.
Missouri General Pretreatment Regulation	10 CSR 20-6.100	Provides for procedures to prevent the introduction of pollutants into publicity-owned treatment work (POTWs).	Applicable	To the extent waters are encountered during cleanup, and disposal to a POTW is chosen, pretreatment requirements will be met.
Missouri Storm Water Regulations: Surface Runoff and Erosion Control; Missouri Storm Water Discharge Regulations	10 CSR 20-6.200 10 CSR 20-6.010(13)	Provides for the use of best management practices to control storm water, erosion control and sediment transport.	Relevant and Appropriate	To the extent storm waters are encountered during cleanup, they will be treated as required to meet substantive discharge criteria. Substantive surface control measures will be implemented as appropriate, although a state permit, per se, will not be obtained.
Standards for Construction, Monitoring and Plugging of Wells	10 CSR 23-3	Provides procedures for constructing, monitoring and plugging of wells.	Relevant and Appropriate	Ground water monitoring wells will be installed and operated consistent with substantive procedures, but permits will not be obtained.
Uranium Mill Tailings Radiation Control Act (UMTRCA) (October 1992)	40 C.F.R. 192.02 Table 1 to Subpart A	Table 1 describes maximum concentrations of constituents for ground water protection, including 0.05 and 0.01 mg/l arsenic and cadmium, and 5 pCi/l for radium-226 and radium-228 and 30 pCi/l for uranium-234 and uranium-238, respectively.	Relevant and Appropriate	Only Table 1 of this regulation is relevant and appropriate as it provides concentration limits that will trigger assessment of the B unit ground water if exceeded.
Clean Air Act, National Emission Standards for Radionuclide Facilities licensed by the NRC and Federal Facilities not covered by subpart H	40 C.F.R. Part 61 Subpart I	Emission levels shall not exceed an effective dose equivalent of 10 mrem/year	Relevant and Appropriate	These regulations are considered relevant and appropriate to the extent necessary to ensure emissions during construction activities meet regulatory limits.

10.3 COST EFFECTIVENESS

The selected remedy is the most cost-effective of the alternatives because it provides the best balance between cost and risk reduction. Alternative 6 successfully removes soils above cleanup criteria in current and potential future use areas, thus eliminating the most likely exposure pathways without unnecessary removal of soil. Additionally, the selected alternative will minimize liability associated with future remedial or protective actions necessary to accommodate future operational activities.

Total present worth cost for the selected alternative is estimated at $114 million. In consideration of these factors, the selected remedy provides the best overall effectiveness of all alternatives evaluated proportional to its cost. SLDS has been identified as a possible value engineering study area. Value engineering studies will be conducted as appropriate in order to maximize its cost effectiveness.

10.4 UTILIZATION OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT TECHNOLOGIES OR RESOURCE RECOVERY TECHNOLOGIES TO THE MAXIMUM EXTENT PRACTICABLE

The selected remedy for SLDS provides a permanent solution to contamination that currently exists on these properties. The selected remedy provides the best balance of trade-offs among the alternatives with respect to the evaluation criteria. The criteria that were most critical in the selection of Alternative 6 were cost effectiveness and overall protection of human health. Expenditures of large sums beyond that required by Alternative 6 would result in negligible reduction in dose.

The state, as well as the community, has expressed a strong preference for removal and out-of-state disposal. The selected remedy meets the statutory requirement to utilize permanent solutions and treatment technologies to the extent practicable. Treatment has not been demonstrated capable of achieving cleanup criteria for the SLDS soils. Soils in north St. Louis County have been tested using soil washing technologies. While high percent removal efficiencies were obtained, the composite criteria (ARAR based) could not be reached. Thus excavated soil, if treated, would still need to be disposed offsite following treatment. It is anticipated that sufficient backfill below deep-soil criteria (risk-based) will be obtained in the upper 4 or 6 feet to completely fill excavations to those depths without treatment.

11 EXPLANATION OF SIGNIFICANT CHANGES

The PP provided for involvement with the community through a document review process and a public comment period. A public meeting was advertised and held on April 21, 1998. Comments that were received during the 30-day public comment period are addressed in Appendix A of this Record of Decision.

Review of State and community comments indicates that all respondents preferred Alternative 6 in lieu of Alternative 4 as stated in the Proposed Plan. Stakeholders consisting of the State of Missouri, City of St. Louis, County of St. Louis and St. Louis Oversight Committee, and Mallinckrodt, Inc. were universally supportive of adoption of Alternative 6.

Upon further investigation it was determined that substantial additional costs would expect to be incurred by the government for Alternative 4 to support future monitoring and disposal considerations. Depending on the precise nature of Mallinckrodt construction activities, cost associated with excavation of contaminated soils and related studies may result in long-term costs for Alternative 4 which equal or exceed those of Alternative 6. This status, together with reduced operational impacts reduction in residual site risk, and consistent with state and community recommendations, Alternative 6 was selected. Residual site risks are substantially reduced for both an industrial/construction worker and for a utility worker due to the increased depth of excavation.

As a result of community comments, the remedy selected was changed to Alternative 6, Selective Excavation and Disposal. The preferred remedy in the initial draft Proposed Plan was Alternative 4. Based on public and stakeholder comments, Alternative 4 was not considered to be sufficiently protective considering the high possibility of construction activities intruding below a 2 foot depth interval. Additionally, concern was expressed regarding the open-ended liability for handling and disposal of wastes excavated from below 2 feet as a result of future activities. Alternative 6, as the preferred alternative, satisfactorily addresses these concerns and comments.

Therefore, Alternative 6 was selected pursuant to State and community comments to reduce future government costs for monitoring; impact and costs of disposal of contaminated soil carried to the surface by excavation activities; and operational impact on land owner's construction efforts. Use of Alternative 6 also substantially reduces residual site risks to construction/industrial workers on the site by minimizing exposure associated with soil excavation and overall access to radioactive material present in soil.

Building decontamination (buildings 25 and 101) will be included in a separate CERCLA action. This was done because, like the inaccessible soils, the building remediation would have to be deferred until the owner makes it available. The buildings and inaccessible soils will be managed through institutional controls until such time as they are otherwise addressed under a future CERCLA action. In addition, questions have arisen regarding whether contaminated buildings 25 and 101 may be addressed under CERCLA.

12 RESPONSIVENESS SUMMARY

Numerous comments were received during the public comment period. In general these comments indicated overwhelming support by stakeholders for Alternative 6 instead of Alternative 4.

Many specific technical issues were also identified for consideration by USACE in developing the final remedial action design. The complete responsiveness summary to these comments is provided in Appendix A.

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