ORIGINAL

Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-91OR21949

Work Plan-Implementation Plan for the Remedial Investigation/ Feasibility Study-Environmental Impact Statement for the St. Louis Site

St. Louis, Missouri

August 1993

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ORIGINAL

WORK PLAN-IMPLEMENTATION PLAN FOR THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY-ENVIRONMENTAL IMPACT STATEMENT FOR THE ST. LOUIS SITE

ST. LOUIS, MISSOURI

AUGUST 1993

Prepared for

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Oak Ridge Operations Office

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By

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FOREWORD

This work plan-implementation plan (WP-IP) has been prepared to document the actions and evaluations made during the scoping and planning phase of the remedial investigation/feasibility study-environmental impact statement (RI/FS-EIS) conducted at the St. Louis, Missouri, site. Remedial action at the St. Louis site is being planned as part of the Department of Energy's (DOE) Formerly Utilized Sites Remedial Action Program.

Because portions of the St. Louis site are on the Environmental Protection Agency's (EPA) National Priorities List, the response actions (i.e., removal actions and remedial actions) to be carried out by DOE at the site are subject to review by EPA, the Missouri Department of Natural Resources, and the public under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act. Section 120(a)(1) of CERCLA as amended clarified the applicability of CERCLA to hazardous sites owned or controlled by federal departments and agencies; thus remedial actions at hazardous DOE sites must satisfy the requirements of CERCLA. Executive Order 12580 delegated to DOE the authority to conduct CERCLA response actions at sites under its control. Consistent with this order, DOE is the lead agency for remedial actions at the St. Louis site. DOE plans and activities for the site are being overseen by EPA Region VII, and a formal interagency agreement coordinating DOE's and EPA's respective roles has been signed. The major elements of the agreement are described in Subsection 1.4.2.

CERCLA requires that an RI/FS be performed to support the evaluation and selection of remedial action alternatives. It is DOE policy to integrate National Environmental Policy Act (NEPA) values with the procedural and documentation requirements of CERCLA. DOE has determined that an environmental impact statement (EIS) is the appropriate level of NEPA review for the St. Louis site. The EIS IP provides guidance to DOE for the preparation of an EIS and records the results of the scoping process for remedial actions at sites for which it has responsibility. This integrated NEPA/CERCLA WP-IP (1) summarizes site-specific background and characterization data, (2) identifies the types and amounts of contaminants at the site and presents a conceptual site model that identifies potential routes of

human exposure to these contaminants, (3) identifies data gaps and delineates how planned activities will satisfy data needs, and (4) describes the approach that will be used to evaluate potential remedial action alternatives. This WP-IP also describes project organization and project controls and provides schedules for tasks to be performed to address both CERCLA requirements and NEPA values. Nothing in this WP-IP is intended to represent a statement on the legal applicability of NEPA to remedial actions under CERCLA.

The conclusion of the RI/FS-EIS process is the issuance of a record of decision that states what remedial action alternative will be conducted at the site to control or alleviate problems associated with contamination for which DOE is responsible.

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ACRONYMS

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
BNAE	base/neutral and acid extractable
BNI	Bechtel National, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CRP	community relations plan
CSR	Code of State Regulations
DOE	Department of Energy
DOE-ORO	Department of Energy-Oak Ridge Operations Office
DQO	data quality objective
EE/CA	engineering evaluation/cost analysis
EIS	environmental impact statement
EP	extraction procedure
EPA	Environmental Protection Agency
EWDAA	Energy and Water Development Appropriations Act
FFA	federal facilities agreement
FS	feasibility study
FUSRAP	Formerly Utilized Sites Remedial Action Program
GC/MS	gas chromatography/mass spectrometry

ACRONYMS

(continued)

HISS	Hazelwood Interim Storage Site
ISA	*Initial Screening of Alternatives*
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineer District
MSL	mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NRC	Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities
ORNL	Oak Ridge National Laboratory
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDCC	Project Document Control Center
PEIS	programmatic environmental impact statement
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFW	Roy F. Weston, Inc.
RI	remedial investigation
ROD	record of decision
SAIC	Science Applications International Corporation

ACRONYMS

(continued)

SFMP	Surplus Facilities Management Program
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
SRM	standard reference material
TBC	to-be-considered
TCL	Target Compound List
TCLP	toxicity characteristic leaching procedure
TMA/E	Thermo Analytical/Eberline
TOC	total organic carbon
TOX	total organic halides
VOC	volatile organic compound
WBS	work breakdown structure
WIPP	Waste Isolation Pilot Plant
WP-IP	work plan-implementation plan

UNITS OF MEASURE

C	Celsius
Ci	curie
cm	centimeter
cms	cubic meters per second
cpm	counts per minute
dpm	disintegrations per minute
F	Fahrenheit
ft	foot
g	gram
gpm	gallons per minute
h	hour
ha	hectare
in.	inch
kg	kilogram
km	kilometer
L	liter
lb	pound
m	meter
μCi	microcurie
meq	milliequivalent
MeV	million electron volts
μg	microgram
mg	milligram
mi	mile
ml	milliliter
μmhos	micromhos
mm	millimeter
mph	miles per hour
μR	microroentgen
mR	milliroentgen
mrad	millirad

UNITS OF MEASURE

(continued)

mrem	millirem
mSv	millisievert
oz	ounce
pcf	pounds per cubic foot
pCi	picocurie
ppb	parts per billion
ppm	parts per million
rem	roentgen equivalent man
s	second
WL	working level
yd	yard
yr	year

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) is conducting a comprehensive review and analysis leading to remedial action for a set of properties located in Hazelwood, Berkeley, and St. Louis, Missouri, under the Formerly Utilized Sites Remedial Action Program (FUSRAP). The properties, collectively referred to as the St. Louis site, are:

- the St. Louis Downtown Site (SLDS) and vicinity properties,
- the St. Louis Airport Site (SLAPS) and vicinity properties, and
- the Latty Avenue Properties [Hazelwood Interim Storage Site (HISS), Futura Coatings, Inc., and vicinity properties].

The vicinity properties are residential, commercial, and municipal properties near SLDS, SLAPS, and the Latty Avenue Properties that were radioactively contaminated as a result of uranium processing at SLDS and subsequent transportation to and storage of processing residues at SLAPS and HISS. HISS, operated by DOE, is a temporary storage site currently owned by Jarboe Realty and Investment Company. Excavated soils from several properties in the vicinity of HISS are currently stored at HISS pending a decision on their final disposition.

FUSRAP was established in 1974 by the U.S. Atomic Energy Commission (AEC), a predecessor of DOE. The major goal of decontamination under FUSRAP is to eliminate potential hazards to the public and the environment from sites containing residual contamination remaining from activities carried out under contract to the Manhattan Engineer District (MED) and AEC or at other sites that Congress has authorized DOE to remedy. The primary authorizing legislations for FUSRAP are the 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); the Atomic Energy Act of 1954; and the Energy and Water Development Appropriations Acts (EWDAA) of 1984 and 1985, which added four sites to the program. A more detailed history of the St. Louis site is presented in Subsection 2.2.

SLAPS, the SLAPS vicinity properties, and the Latty Avenue Properties have been placed on the Environmental Protection Agency's (EPA) National Priorities List, a list of sites identified for remedial action under CERCLA as amended by the Superfund Amendments and Reauthorization Act, hereinafter referred to simply as CERCLA.

This document is intended to (1) provide background information on the St. Louis site, (2) present available information on the types and extent of contamination present on the site, (3) describe the proposed steps leading to final remedial action, and (4) provide an opportunity for public input to the remedy selection process.

1.1 GENERAL SITE INFORMATION

The general locations of SLDS, SLAPS and its vicinity properties, and the Latty Avenue Properties are shown in Figure 1-1. SLDS, currently owned by Mallinckrodt, Inc., is located on the eastern border of St. Louis, near the Mississippi River. SLAPS lies immediately north of Lambert- St. Louis International Airport, east of Coldwater Creek. Near SLAPS are 94 residential and commercial vicinity properties, some of which are radioactively contaminated as a result of MED/AEC activities, material transfer, utility line construction, and flooding. The Latty Avenue Properties are within the city limits of Hazelwood and Berkeley, 3.2 km (2 mi) northeast of the control tower of the airport. Detailed descriptions of the properties are presented in Subsections 2.1 and 2.3.

SLDS is an 18.2-ha (45-acre) tract located in a highly industrialized area. Ten plants currently operating at the facility produce various chemical products. From 1942 to 1957, several MED/AEC operations were conducted at the facility, including processing and producing various forms of uranium compounds and pure uranium metal. Radiological surveys conducted thus far have shown that portions of the facility have alpha and beta-gamma levels exceeding current federal guidelines (ORNL 1981, BNI 1990a). The major radioactive contaminants at SLDS are uranium-238, radium-226, and thorium-230. Concentrations in soil range from 1.3 to 95,000 pCi/g and 0.4 to 5,400 pCi/g for uranium-238 and radium-226, respectively. Thorium-230 concentrations range from 0.3 to 98,000 pCi/g (BNI 1990a). Surveys of six vicinity properties associated with SLDS

identified five of them as radioactively contaminated. Subsections 2.1.1, 2.2.1, and 2.4 provide additional information on SLDS and its vicinity properties.

SLAPS, owned by the City of St. Louis, is an 8.8-ha (21.7-acre) tract located 24 km (15 mi) northwest of downtown St. Louis and 0.8 km (0.5 mi) south of HISS. In 1946 MED acquired SLAPS to store residues from uranium processing conducted at SLDS. The property was fenced to prevent public access. Most of the wastes and residues were stored on open ground, although some contaminated materials and scrap were buried at the western end of the property. Surveys conducted since 1976 indicated elevated concentrations of uranium-238, radium-226, thorium-230, and thorium-232 (ORNL 1979, BNI 1987a). The characterization at SLAPS conducted by Bechtel National, Inc. (BNI) from 1986 to 1990 showed radioactive contamination at depths as great as 5.5 m (18 ft). Soil analyses identified elevated levels of radium-226, thorium-230, thorium-232, and uranium-238 ranging from less than 0.3 to 2,700 pCi/g, 1.0 to 2,600 pCi/g, less than 0.5 to 50.4 pCi/g, and less than 3.0 to 1,600 pCi/g, respectively (BNI 1987a). Subsections 2.1.2, 2.2.2, and 2.4 provide additional information about SLAPS and its vicinity properties.

The Latty Avenue Properties are composed of HISS on the eastern side, Futura Coatings on the western portion, and vicinity properties; HISS and Futura, currently owned by Jarboe Realty and Investment Company, cover approximately 4.5 ha (11 acres). In 1966 Continental Mining and Milling of Chicago, Illinois, purchased process wastes at SLAPS and stored them at the Latty Avenue Properties during 1966 and 1967. Between 1967 and 1973, most of the residues were dried and shipped to Canon City, Colorado. Various excavations and renovations were conducted at the Latty Avenue Properties in the late 1970s. Currently, contaminated debris and soil from these decontamination efforts are stored at HISS. BNI characterization studies at HISS and Futura showed thorium-230 as the major contaminant, with smaller amounts of uranium-238 and radium-226. At HISS, thorium-230 concentrations range from 0.8 to 790 pCi/g; at Futura, concentrations range from 1.1 to 2,000 pCi/g (BNI 1987b,c). Subsections 2.1.3, 2.2.3, and 2.4 provide additional information about the Latty Avenue Properties.

In 1985 DOE directed Oak Ridge National Laboratory (ORNL) to perform a radiological survey of the roads thought to have been used to transport contaminated materials to SLAPS and HISS, including parts of Hazelwood Avenue, Pershall Road, and McDonnell Boulevard. Results showed gamma radiation exposure rates in excess of background levels, and results for soil showed thorium-230 to be the major contaminant (ORNL 1986a).

Surveys of the properties conducted before the BNI characterization indicated radioactive contamination in excess of current DOE guidelines and spelled out the need for further study. ORNL conducted surveys at SLDS in 1977, at SLAPS from 1976 to 1978, and along Latty Avenue in 1981 and 1984 (ORNL 1981, ORNL 1979, ORNL 1986b,c). The latest BNI characterization studies, more comprehensive in their scope than earlier surveys, showed some radionuclide concentrations in excess of currently acceptable guidelines on approximately two-thirds of the properties surveyed.

Surveys of all vicinity properties associated with SLAPS and the Latty Avenue Properties have shown thorium-230 to be the major contaminant, even though in certain spots, other radionuclides are considered contaminants of concern (BNI 1990b).

Although some areas of radioactivity in soil at SLDS, SLAPS, HISS, and Futura were found to be several times higher than the applicable DOE residual radioactivity guidelines, there appear to be no immediate health risks to workers or people living in the vicinity of these properties, given current property use. In general, levels of radioactivity in soil are low across most of these properties. In addition, access to these properties is restricted, and members of the general public are not allowed entry.

Given the low levels of radioactivity in soil on the vicinity properties (substantially lower levels than found in the restricted areas) and the current land use, there appear to be no immediate health risks to property occupants. For a more detailed discussion of the contaminants of concern and any associated health risks, see Section 3.0.

Because of the extensive amount of information already known about the St. Louis site (including sampling and analysis data, the history of uranium processing at SLDS, the types of ores and chemicals used in the actual processing, and the transport of waste materials from SLDS to SLAPS and HISS), extensive additional sampling should not be required to begin evaluation of alternatives for remedial action.

1.2 JUSTIFICATION AND OBJECTIVES FOR THE PROPOSED ACTION

The primary threat to human health and the environment associated with the St. Louis site is the potential for uncontrolled release of contaminants from exposed surfaces and subsurface disposal areas. Possible mechanisms that could result in release of contaminants are infiltration and percolation, wind dispersal, gaseous emissions, surface runoff, and disturbance by humans or animals (see Section 3.0). Direct exposure to gamma-emitting radiation at the site is also a possibility. Release from the materials currently stored at HISS and SLAPS could occur, e.g., as a result of discontinuation of facility maintenance in the future. Therefore, permanent disposition of stored materials and cleanup and disposition of currently uncontained materials are necessary for the long-term protection of human health and the environment in the area.

The overall objective of remedial action at the St. Louis site is to eliminate, reduce, or otherwise mitigate the potential for exposure to radioactive and chemical contaminants. Specific objectives of the remedial action process are to:

- thoroughly delineate the boundaries of contamination at the site,
- assess potential risks to human health and the environment that could result from exposure to site contaminants,
- minimize potential health hazards to personnel conducting characterization and remedial action activities,
- mitigate any immediate hazards associated with site conditions, and
- assess potential remedial action alternatives and select and implement a permanent remedy.

All remedial action activities at the St. Louis site will be conducted in accordance with CERCLA and applicable or relevant and appropriate requirements (ARARs) (see Subsection 3.9).

1.3 ENVIRONMENTAL COMPLIANCE PROCESS

Remedial and removal actions that will be conducted by DOE at the St. Louis site are being coordinated with EPA Region VII under CERCLA. It is DOE policy to integrate the requirements of CERCLA with the values of the National Environmental Policy Act (NEPA) for remedial actions at sites for which it has responsibility. The remedial investigation/ feasibility study (RI/FS) conducted under CERCLA is the primary process for environmental compliance associated with DOE remedial actions. Under this integrated policy, the CERCLA process is supplemented, as appropriate, to incorporate NEPA values. This integrated work plan-implementation plan (WP-IP) outlines the approach for evaluating remedial action alternatives at the St. Louis site.

A key element of the integrated CERCLA/NEPA process is to determine the level of environmental analysis appropriate under NEPA. This determination is a function of many factors, including the complexity of a proposed action, the likelihood for significant environmental impacts, and the potential for considerable public interest. DOE has determined that an environmental impact statement (EIS) is the appropriate level of NEPA review for the St. Louis site. Thus, DOE is preparing an RI/FS-EIS for the St. Louis site to determine the nature and extent of existing contamination and to evaluate alternative response actions.

Interim response actions (i.e., removal actions taken before completion of the RI/FS-EIS process) are possible for the St. Louis site. Typically, these interim actions involve removal of contaminated materials from an area and subsequent interim storage pending selection of a comprehensive remedy for wastes generated by cleanup of the St. Louis site. Removal actions currently projected include cleanup of contaminated materials from vicinity properties at SLAPS and SLDS and subsequent temporary storage of

the resulting materials. Interim response actions will be conducted in accordance with DOE's CERCLA/NEPA integration policy.

This RI/FS-EIS WP-IP describes the history, environmental setting, and nature and extent of contamination at the St. Louis site (Section 2.0) and presents an initial evaluation of contamination at the site (Section 3.0). This evaluation addresses potential contaminant sources, environmental transport mechanisms and receptors, and data gaps. In addition, the WP-IP identifies preliminary response objectives, technologies, and alternatives for site remediation (Section 3.0). Activities planned to obtain the data needed for completion of the RI/FS-EIS process and the 14 standard tasks for completing an RI/FS-EIS are also presented (Sections 4.0 and 5.0). Finally, the WP-IP describes the organization, project controls, and schedules that will be employed to fulfill the requirements of the proposed studies (Sections 6.0 and 7.0).

1.4 EXTERNAL INVOLVEMENT

1.4.1 Coordination with Other Agencies

Executive Order 12580 delegated to DOE the authority to conduct remedial action at sites under its control. Consistent with this order, DOE is the lead agency for remedial action at the St. Louis site. DOE plans and activities for the site are being overseen by EPA Region VII and are also being coordinated with appropriate Missouri state agencies, including the Missouri Department of Natural Resources (MDNR). Through the community relations plan (CRP) for the St. Louis site, DOE also provides for the participation of federal and state legislators, local and county officials, and the general public in the decision-making process for site remediation.

DOE has initiated and will continue routine meetings with EPA and MDNR to discuss plans and other information relevant to the RI/FS-EIS. Site tours have been given to representatives of EPA Region VII and MDNR, and because extensive RI work has already been conducted at the site, a bibliography of related literature has been provided so that agencies can request copies of these reports.

DOE and other federal agencies have prepared EIS documents for other programs that are similar to this RI/FS-EIS effort; a list of these documents is provided in Appendix A.

1.4.2 Summary of the Federal Facilities Agreement

DOE and EPA Region VII negotiated a federal facilities agreement (FFA) defining the specific responsibilities and interactions of both agencies regarding DOE's remedial action activities at the St. Louis site. The final agreement was signed in June 1990.

The FFA states that the intent of the agreement is to:

- ensure that the environmental impacts associated with past and present activities at the St. Louis site are thoroughly investigated and that appropriate remedial action is taken as necessary to protect public health or welfare and the environment;

- establish a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions at the St. Louis site in accordance with CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and Superfund guidance and policy; and

- facilitate cooperation, exchange of information, and participation of the parties in such actions.

In addition, specific elements of the agreement are included to:

- identify operable unit alternatives that are appropriate for the site before implementation of the final remedial action(s);

- establish requirements for the performance of an RI to fully determine the nature and extent of the threat to public health or welfare and the environment caused by the release or potential release of FUSRAP waste at the site;

- establish requirements for the performance of an FS to identify, evaluate, and select alternatives in accordance with CERCLA for the appropriate remedial actions(s) to prevent, mitigate, or abate the release or potential release of FUSRAP waste at the site;

- identify the nature, objectives, and schedule of response actions to be taken at the site (response actions will attain the degree of cleanup mandated by CERCLA for hazardous substances, pollutants, or contaminants;

- implement the selected remedial action(s) in accordance with CERCLA, the NCP, and Executive Order 12580;

- provide for operation and maintenance of any remedial action(s) selected, as necessary; and

- ensure compliance with federal and state hazardous waste laws and regulations for matters covered by the FFA.

As defined in the FFA, "FUSRAP waste" is specifically limited to:

- all wastes including but not limited to radioactively contaminated wastes resulting from or associated with uranium manufacturing or processing activities conducted at the St. Louis site, and

- all radioactive contamination related to past uranium processing at SLDS and exceeding DOE remedial action levels on any vicinity property.

Also included is any chemical contamination on vicinity properties that either:

- is mixed or commingled with radioactive contamination exceeding DOE action levels, or

- originated at SLDS or was associated with specific uranium processing activities at SLDS that resulted in the radioactive contamination.

1.4.3 Public Participation

DOE is committed to a program of public participation in the remedial action process for the St. Louis site. A formal CRP has been developed as an ancillary document to this WP-IP. The CRP describes a program to gather information from the affected community, inform the public of ongoing and planned activities, and facilitate public input to the decision-making process. Through this program, DOE interacts with the public using such mechanisms as news releases and fact sheets, public meetings, discussions with local interest groups, response to public comments, and maintenance of a public repository for documents and information related to the site. The CRP is discussed in further detail in Subsection 5.2.

1.5 SCOPING PROCESS

1.5.1 Introduction

One of the primary purposes of this WP-IP is to document how DOE intends to address the comments received during scoping and how to implement them into the combined RI/FS-EIS process. This WP-IP presents DOE's responses to public comments for the environmental review and analysis of the St. Louis site under FUSRAP.

Part of the environmental-cleanup scoping and planning phase of the RI/FS-EIS process is to provide an opportunity for residents living in the communities surrounding the St. Louis site, as well as other interested parties, to participate and comment on the ongoing environmental studies. DOE issued a draft-final version (approved by EPA per the FFA) of the St. Louis work plan for public comment and held a public scoping meeting on January 28, 1992, at the Berkeley Senior High School in Berkeley, Missouri. Written comments were submitted to Lester K. Price, DOE's director of the Former Sites Restoration Division at the Oak Ridge Operations Office in Oak Ridge, Tennessee. The following summary includes DOE's responses to the testimony recorded in the official transcript of the

January 1992 meeting and to comment letters received before and after the meeting. The summary also integrates responses to comments specifically applicable to the St. Louis site that were made at the December 6, 1990, programmatic environmental impact statement (PEIS) scoping meeting.

DOE values public input into the overall cleanup process and encourages participation by all interested parties. DOE would like to express its appreciation to all who attended the public meetings and gave their comments both verbally and in writing.

Many issues dealing with the criteria used to evaluate an alternative for final cleanup were raised by the citizens. Concerns were voiced on issues such as exposure risk, economic impact, land use considerations, disposal site selection, and cost—all of which will be taken into consideration in preparing the RI/FS-EIS detailed analysis. For the purpose of presenting a succinct response to the questions on related issues, all public inquiries were grouped under 11 key subject areas:

- schedule and pace of cleanup,
- safety and health concerns,
- interim cleanup measures,
- storage and disposal site selection,
- other sites,
- public participation in the cleanup process,
- economic issues,
- land-use issues,
- transportation issues,
- extent of contamination, and
- data quality and sufficiency.

The format used to address particulars within each key subject area consists of a set of composite questions representing a synthesis of the public's concern on a given issue. For each of these 11 key areas, reviewer comments were consolidated into general and St. Louis site-specific questions and responses. Each general question and response is, when

appropriately needed to fully address the public comments, immediately followed by the related St. Louis site-specific question(s) and response(s). The St. Louis site-specific questions are underlined. In many instances, questions are followed by text in italics, which attempts to capture the range of comments used to formulate the composite question. The DOE response is given after the question or italicized text.

Overview of Comments

Table 1-1 and Figure 1-2 summarize the nature of the public comments received from the December 6, 1990, and January 28, 1992, public scoping meetings and those received in writing. In Table 1-1, the 11 key subject areas are broken out into sub-comments, and the number of comments received for each sub-comment is provided. In Figure 1-2, the 11 key subject areas are plotted to indicate the relative extent of comments for each area. Figure 1-2 shows, in terms of the number of comments, that the areas with the highest levels of public concern are storage and disposal site selection and safety and health concerns. The next highest levels fall at schedule and pace of cleanup and other sites.

1.5.2 Comments on Schedule and Pace of Cleanup

Why does environmental cleanup take so long?

Many citizens stated that the timetable for environmental studies and cleanup is too long and that swift and immediate action is needed.

DOE response: The schedule set up for cleanup of a site must be consistent with the requirements of CERCLA. The timetable and schedule must be such that the remediation is performed safely, effectively, and in a environmentally sound manner. DOE must comply with the requirements for environmental studies and interactions with the public before selecting and implementing an alternative. Alternatives to accelerate the schedule such as interim cleanup removal actions are being explored whenever possible.

Why is the St. Louis cleanup schedule taking so long?

It was suggested that DOE needs to respond to the wishes of St. Louis citizens as expressed in a November 1991 referendum. Congressional action was suggested as a means of giving the St. Louis site the priority it deserves. Concern was expressed that the St. Louis areas slated for cleanup were identified as among the most pressing in the nation, yet citizens perceived that little was being done.

DOE response: The St. Louis site schedule is complying with congressionally established CERCLA and NEPA regulations. The schedule was negotiated with EPA and established as part of the FFA, docket number V11-90-F-0005, signed by EPA in June 1990. The FUSRAP schedule is given in Table 1-2.

An interim removal action effort to accelerate the cleanup of some private properties, prior to EPA's concurrence with the record of decision (ROD), was pursued by DOE. This involved preparing an engineering evaluation/cost analysis (EE/CA), which was issued for public review in March 1992. The EE/CA document outlined how removal actions could be performed at residential and municipal vicinity properties to free them of contamination. It was proposed that the waste material be temporarily stored at HISS. This proposal was not adopted, due to local officials' concerns with adding waste to the HISS piles. The EE/CA is being re-evaluated in an attempt to obtain a mutual agreement between DOE and local officials on the removal actions. Since a permanent disposal facility is not currently licensed to accept this waste, temporary storage at HISS is the only option. Such early removal actions will be pursued in the future to help speed the removal of limited amounts of waste.

Why doesn't DOE move up the date for the St. Louis site record of decision?

St. Louis citizens expressed that they did not want to wait three years for a ROD. Commenters suggested that the date be moved up to as early as March 1993.

DOE response: CERCLA and NEPA studies, documentation, and public involvement activities required for the St. Louis site dictate scheduling of the ROD. The most recent RI

studies were completed in 1989 to identify the characteristics and boundaries of contamination. This information is needed to prepare the federally required baseline risk assessment, FS-EIS, and proposed plan documents for the St. Louis site. Only after public comments on the FS-EIS and the proposed plan have been addressed can the ROD package be completed. The baseline risk assessment, FS-EIS, and proposed plan are currently scheduled to be made available to the public in late 1993.

Do DOE staff changes affect the schedule?

One speaker complained that over the past 10 years he has witnessed many DOE staff changes and several public hearings, but he has seen no progress.

DOE response: Personnel changes in DOE, as well as with its contractors, do not affect the established timetable and milestones negotiated and agreed upon with EPA in FFAs. All personnel and contractors are required to adhere to this federally mandated schedule.

How are priorities set for cleaning up different sites?

Some citizens felt that sites near certain communities are not being cleaned up as quickly as others. They wanted to make sure that all citizens are treated fairly. Some citizens were also concerned about how priorities for cleanup alternatives were set and areas for cleanup selected.

DOE response: Priorities for cleanup are based on the risk to human health and the environment, the magnitude of the cleanup required, and the money available to fund it. In most instances, residential and other private properties are given priority over commercial and government property. When a situation exists that is an immediate threat to human health or the environment, an expedited response or remedy will be implemented in the interim while a permanent solution is determined.

Does DOE consider several alternative cleanup plans simultaneously?

Primarily, speakers sought expedient solutions and wanted to know that multiple alternatives are being considered simultaneously to avoid further delays.

DOE response: Multiple cleanup alternatives are evaluated simultaneously during the FS-EIS process. Description of the alternatives and discussion of their attributes, including implementability, will be presented for public comment in the FS-EIS and proposed plan for the site.

Will the public be notified prior to the onset of cleanup actions?

One citizen wanted to be notified before cleanup actions (and potential increased risks associated with them) begin.

DOE response: As part of the combined CERCLA and NEPA process, the public will be notified of planned cleanup actions through media releases. Notification will also be made to public utilities, emergency response facilities, and municipal offices prior to the start of cleanup actions.

1.5.3 Comments on Safety and Health Concerns

Why are areas treated safe in the past, now protected as if they are dangerous?

Concerns were expressed that workers in the past were not properly informed of the risks as they are now understood. Numerous statements were made, such as "My husband used to play in this pile when he was little and everyone said not to worry about it, it was safe. Yet, now they've covered the area with plastic," and "When a strong wind struck a couple of years ago, they used fire trucks to wet it down because it was blowing all over." Others cited incidences of cancer in areas adjacent to contamination.

DOE response: Early scientists involved in radiological research and technological development did not have a comprehensive understanding of the potential risks associated with exposure to radioactive materials. Many potential health hazards associated with the handling of contaminated materials and soils were not fully understood. As concern and understanding of human health and environment has grown, measures and guidelines have been put in place to reduce public and worker exposure risks. Current knowledge of these risks far surpasses what was then known.

The understanding and knowledge of radioactive materials and the associated health effects they have on the public have evolved over time. More stringent standards have been imposed by regulatory agencies as modern thought has suggested that even low risks should be minimized. To ensure public safety, additional precautions in handling and storing radioactively contaminated soil have been implemented. Covering storage piles, wetting down soil to prevent airborne particulates, and environmental monitoring are all done to provide maximum control of the material until a permanent cleanup alternative is implemented.

The baseline risk assessment, a component of the environmental cleanup process, evaluates potential risks to human health and the environment associated with contamination at the properties composing the FUSRAP site. The calculated risk analysis in this document included addressing the incidence of cancer in the exposed populations.

What can be done to safeguard human health in areas known to be contaminated at the St. Louis site?

Citizens pointed out that there were areas where children and others could be exposed to contaminants. For example, children have been known to play along vicinity properties, and workers occasionally need to provide maintenance to utilities. What precautions can be taken for their welfare?

DOE response: As part of the combined CERCLA and NEPA process, DOE will evaluate in detail the potential health impacts of current conditions and future actions. Areas where the

public could be exposed to contamination currently pose no unacceptable health threat to the environment or the citizens in the area under the present conditions. Until a permanent cleanup of the sites is conducted, DOE has suggested to property owners (private, commercial, and municipal) that they notify DOE of any activity that could disrupt contaminated areas. DOE will provide assistance to help ensure the required activity is done safely and protects human health and the environment. Numerous activities have already been conducted under this approach.

Shouldn't signs be posted at Coldwater Creek that alert people, especially playing children, of contamination?

DOE response: DOE does not believe signs are necessary since analysis has shown that the creek does not pose a significant risk. An assessment was done of the risk to children playing in the creek. The scenario postulated that a child visited the creek frequently and, while playing, actually ingested some of the most contaminated soils. The analysis results indicated that the creek is safe in its current condition. The results from this assessment will be presented in the draft RI/FS-EIS document, which is scheduled to be released for public comment in early 1994.

How can we be sure that cleanup activities will pose no threat to the people in the highly populated St. Louis area?

Citizens expressed concern that the material presently stored at the Berkeley/Hazelwood area and at Hazelwood Interim Storage Site currently presents a risk to the health of citizens and to the environment.

DOE response: The DOE program has multiple safeguards built into cleanup activities. Currently, institutional controls and physical measures are being used at SLDS, SLAPS, the Berkeley-Hazelwood area, and HISS to control the risk to human health and the environment of the region. These controls include site security such as fences, signs, the use of interior surface sealants, asphalt ground covers, and site personnel controlling access to the areas of contamination.

The results from the baseline risk assessment performed on the St. Louis site show that the HISS pile and SLAPS currently pose no unacceptable health threat to any of the citizens in the area, nor are they posing any threat to the surrounding environment. An extensive environmental monitoring program is currently in place at HISS that requires the frequent sampling of groundwater, surface water, and ambient air. The environmental monitoring program is designed to identify any significant changes to current conditions and will be continued until a permanent solution has been implemented. The potential health impacts of various cleanup alternatives will be evaluated during the FS-EIS process as part of the decision-making process.

What kind of safety measures are there for workers performing cleanup?

One individual wondered why workers dress in protective clothing whenever they enter an area for waste cleanup, yet DOE claims the site poses no health threat to the public. Concern was also expressed about DOE's ability to monitor waste during cleanup action and to minimize the potential exposure of the public and workers.

DOE response: Worker protection is a critical component to any waste cleanup effort. Since the environmental workers spend much of their time working in areas of contamination, their cumulative exposure is much greater than that of a private citizen. Requirements change based on levels of contamination and the type of work being performed. Activities that can create airborne dust, such as work being conducted on a drill rig, could require the use of respirators or protective clothing.

When performing cleanup actions, very sensitive instruments are used continuously to measure the activity levels in the soil. These instruments help to assure that the contaminated soil is removed and that contamination is not spread from the site. Interim storage facilities are used to store and manage waste material generated from site characterization studies and interim remediation efforts. Access to these facilities is restricted to minimize the exposure to the public. Monitoring the environmental conditions around these facilities helps to ensure that the contamination is contained.

What are the risks from radiation to workers at Mallinckrodt Chemical Works?

Citizens were concerned about radiation exposure at Mallinckrodt Chemical works. One citizen asked specifically about the exposure to employees in Building 116 at the Mallinckrodt Chemical Works.

DOE response: Based on a risk assessment completed for the Mallinckrodt Chemical Works site, no workers are expected to receive radiation doses in excess of DOE's radiation protection standard for a member of the public, which is 100 mrem/year above background.

Building 116 is a radiation-controlled area with restricted access and specific monitoring requirements for personnel working inside the building. A person working in Building 116 for 8 h/day, 5 days/week, 52 weeks/year would receive an average exposure of approximately one-fifth of the standard.

What is being done to prevent the further spread of contamination along old haul routes by normal maintenance activities?

Concerns were raised that water main maintenance along old haul routes could result in disturbances of surface and underground contaminants. Possible water main discharges could potentially transport waste out of the present boundaries of contamination.

DOE response: The local water utility is aware of specific areas that may be contaminated along old haul routes. Procedures have been developed by the utility for containment and employee protection in these areas. DOE also has personnel in the local area available on 24-h call in the event of an occurrence.

How do you determine the risks posed by low-level radiation from the waste sites?

Citizens expressed concern about the relationship between low-level radiation from waste sites and cancer deaths. One person wondered if studies were done concerning such waste sites to see how many people have had leukemia, blood disease, or cancer that could

be related to radioactivity. Another citizen was concerned that the people affected by low-level exposure are not being informed of that risk. Another asked how risk assessment worked.

DOE response: The baseline risk assessment document, which is a major component of the RI/FS-EIS process, addresses potential risks to human health and the environment associated with contamination from a number of sources, including low-level radiation. Risks are assessed by quantifying the magnitude of radiological exposure and using accepted methods for estimating health risks associated with these exposures. Various studies and calculated risks for individual sites are included in this document, including potential health risks expressed as an increased incidence of cancer in the exposed population. This document will be part of the administrative record when published along with the FS-EIS and proposed plan.

Is there a safe radiation dose?

Several citizens were concerned that radiation is dangerous and that even low-level radiation poses a greater risk than previously believed. Some cited the work of two radiation experts, the University of California's John Goffman and MIT's Nobel Prize winner Henry Kendall, as well as the National Academy of Science's BEIR V report. Several citizens suggested that exposure to even low levels of radiation is dangerous.

DOE response: Today's scientists have access to an extensive database that includes information regarding health effects stemming from exposure to radionuclides. As a result of our nation's growing concern for the environment, standards have become more stringent for exposure to radionuclides and other hazardous materials. DOE agrees that even low-level exposure probably has some possible risk associated with it. Continued attempts are being made to keep exposure as low as reasonably achievable until a final alternative is chosen and implemented.

How are the radioactivity measurements related?

DOE response: Three different types of measurements are made to characterize the radiation levels in, for example, buildings. Each provides different information, but there is not necessarily a direct correlation among them.

The first type is measurement of the amount of gamma radiation being given off by the radioactive material present. The measurement is taken at a distance, usually 1 m (3.3 ft), from the radiation source (e.g., a floor, wall, or ceiling). It shows the level of gamma radiation inside the room away from the building surfaces. This is typically reported in μR/h.

The second type consists of measuring the amount of alpha radiation. This measurement is made in contact with or very close to the surface (e.g., a floor, wall, or ceiling) and measures only alpha radiation, excluding beta and gamma radiation. This value is typically reported in dpm/100 cm^2.

The third type is a measurement of the combined beta and gamma radiation close to the surfaces. A different type of detector is used, which will give the total beta-gamma radiation levels at contact with or very near the surface (e.g., a floor, wall, or ceiling). This value is also typically reported in dpm/100 cm^2.

Alpha and beta radiation are particulates (i.e., made up of particles instead of electromagnetic waves, like light) and have a limited range. Alpha particles travel approximately 1 cm (0.4 in.) in air before being completely absorbed. Therefore, the measurements made at a greater distance (i.e., those reported in μR/h) will not detect alpha radiation. Beta particles travel a slightly longer distance, perhaps as much as a 1 m (3.3 ft) in air, before being absorbed. They also lose a great deal of energy during that time, so that measurements made at greater distances from the surface [e.g., at least 1 m (3.3 ft)] will probably not detect beta radiation.

Gamma radiation does travel far enough to be detected at longer distances from the source. However, uranium, thorium, and their radioactive daughter products decay primarily through alpha and beta emissions. Since gamma radiation is a relatively minor component of uranium and thorium radioactive decay, the measurements made for beta and alpha radiation at the surface (e.g., floors, walls, and ceilings) are disproportionately larger than the respective gamma measurements.

How is the exposure value related to the dose value cited on page 2-74 of the St. Louis site work plan?

An individual pointed out that the background radiation in St. Louis was about 10 μrad/h, the dose from about 20 dpm. Yet on page 2-74 of DOE's work plan, an exposure of 929,000 dpm was translated into a dose of 10 μrad. How could this much higher exposure be translated into the same dose figure?

DOE response: Page 2-74 of DOE's work plan reports a removable contamination value of 929,000 dpm/100 cm^2. Also reported in this table is an exposure rate of 10 μR/h. Disintegrations per minute (dpm) is a measure of the number of atoms which undergo radioactive decay in a minute. Usually this number is expressed per unit area (or unit of mass) (e.g., dpm/100 cm^2). Microroentgen per hour (μR/h) is a measure of the amount of energy lost in air by the passage of gamma or X rays. The measurements in μR/h taken in St. Louis using a pressurized ionization chamber cannot be directly compared to measurements using a surface detector, which measures in dpm. Other factors, including the specific radionuclides (i.e., gamma vs. beta-gamma) being scanned and the distance from the contaminated area to the source of the instrument, need to be considered when attempting to compare exposure rates to dpm.

What kind of health problems does alpha radiation cause?

A citizen was concerned that alpha radiation can cause health problems when it passes through the body.

DOE response: Alpha radiation is composed of alpha particles (i.e., atomic particles). Alpha particles are not capable of penetrating skin or traveling more than approximately 1 cm (0.4 in.) in air. As the outer layer of our skin is already dead, alpha particles have no damaging effect on it. The health concern with these particles is in their possible ingestion or inhalation, during which the alpha particles could come in contact with sensitive living tissues and cause damage or disease. Extensive measures are taken throughout the St. Louis site to minimize potential inhalation and ingestion exposure. These measures can include personal hygiene, protective clothing, and the use of respirators, and/or design/engineering protection such as surface coatings (paint) or barriers (asphalt, concrete) over contaminated surfaces. Alpha particles tend to attach themselves to dust and smoke particles, so such simple measures as keeping soils damp prevent the particles from being an airborne hazard.

1.5.4 Comments on Interim Cleanup Measures

Why are interim storage measures considered when permanent disposal is needed?

DOE response: Temporary storage is considered because the alternative of no action pending a permanent solution may be less desirable. The desirability of interim storage is evaluated in terms of human health and safety and protection of the environment.

Is interim storage being considered because there is no permanent place to put the waste?

Some participants were concerned that permanent disposal is not the ultimate goal of this program. They sought assurance that specific steps toward that goal are under way.

DOE response: At this time, there is no federally approved facility, permanent and ready, to receive this type of waste [Class 11(e)(2)—a by-product material of uranium or thorium processing], although several facilities have applied for licenses. DOE facilities are not currently authorized to accept the volume of waste that exists at the FUSRAP site. Consequently, interim storage is the only viable option for sites where the no action alternative is not desirable.

There are three main steps in the combined CERCLA and NEPA process that must be completed before a final alternative can be selected: (1) DOE must develop and evaluate a range of cleanup alternatives for cleaning up the FUSRAP site in a set of documents called the RI/FS-EIS; (2) DOE must select its preferred alternative and present it to the public, the state, and EPA Region VII in a document called the proposed plan; and (3) with input from the public, DOE must ultimately decide which alternative will be implemented. This alternative will be presented in the ROD document.

Why is interim storage being used at the St. Louis site?

Citizens said they opposed interim storage, citing several concerns. Some worried that a temporary site might become permanent. Others felt that every time waste is moved, more waste is generated. Others emphatically opposed any kind of interim storage. Additional concerns were voiced that there are no suitable sites available within the community.

DOE response: Currently, HISS provides a secure location where soil resulting from removal actions in the Berkeley/Hazelwood area can be safely stored until the final cleanup alternative is identified in the ROD. Similarly, an interim storage site at SLDS is being used to contain contaminated soil and building materials from excavation and renovation activities at the site. Site-specific health and safety plans establish the safety precautions required to protect workers during the movement of wastes to the storage areas and within them. An environmental monitoring program is in place to monitor any potential exposure to the public.

What happened to the original buildings at the Mallinckrodt Plant utilized for Manhattan Engineer District activities?

DOE response: Numerous buildings underwent decontamination at the Mallinckrodt main plant in the late 1940s and early 1950s. Work was performed and supervised by Mallinckrodt personnel to meet AEC cleanup criteria. A final contamination survey and clearance for unrestricted use of the property was given by AEC personnel from their Health and Safety Division. In the late 1950s all operations at the Mallinckrodt plant were

transferred to Weldon Spring. In the early 1960s decontamination was performed, and AEC again released these buildings for unrestricted use. All contaminated building material was removed by AEC.

Since receiving its property from AEC for unrestricted use, Mallinckrodt has used it for various purposes related to its commercial chemical operation. Some buildings have been torn down, and new ones have been constructed. AEC did not decontaminate radioactivity to background at these buildings, but only reduced it to the "acceptable levels" that were standard at the time. These previous levels are not the same as levels currently recommended for release for unrestricted use. Therefore, some of the buildings at Mallinckrodt will require additional decontamination.

How can we be sure that DOE is really going to clean up the contamination and make our city safe?

Citizens are concerned that, if the radioactive soil is removed from public access during an interim removal action, federal officials may decree the crisis to be resolved and they will refocus their cleanup priorities.

DOE response: Congressional legislation and regulatory requirements of CERCLA and NEPA commit to permanently resolving contamination problems at all FUSRAP sites. Strict schedules, with specific deadlines, have been established and negotiated with EPA. Cleanup alternatives that are environmentally safe and protect human health will be chosen and developed in support of the FS-EIS decision-making process. An interim removal action is simply a way to more fully protect citizens and the environment until that permanent alternative is implemented.

What is being done to make sure that short-term measures are safe and appropriate?

A citizen was concerned that moving waste during removal operations might cause contaminants to migrate or cause gases that can harm people to be released.

DOE response: The combined CERCLA and NEPA process requires that DOE demonstrate that any proposed cleanup measure be protective of human health and the environment before it can be implemented. One example of the controls used to ensure measures to be taken are safe and appropriate is the readiness review. The readiness review process is an integral part of field cleanup activities and is conducted to confirm that all impacts will be appropriately addressed. Technical issues such as the proper handling of waste will be resolved prior to the start of any removal action. Sophisticated radiological field instruments are used to screen vehicles, tools, and personnel to prevent the spreading of contamination. In addition, dust control techniques in combination with controlling public access to areas being remediated will ensure the safety of local residents.

What has been done to address not repeating the Latty Avenue cover tear?

Citizens were upset by the tearing of a cover at the Latty Avenue property in March 1991 and were concerned that such an event could occur again. They wanted to know that DOE is acting responsibly toward the citizens of St. Louis.

DOE response: In March 1991 an unforeseen incident occurred in which the HISS pile cover tore during a storm, where winds greater than 70 mph were recorded. Due to the quick response by onsite personnel, no measurable release occurred. Shortly following this incident, the pile cover was patched, and a newly developed, high-strength biaxial geogrid material made out of high-density polyethylene was secured over the existing pile cover.

1.5.5 Comments on Storage and Disposal Site Selection

Does DOE have plans for permanent storage of radioactive waste in densely populated areas?

Individuals expressed their doubts about the suitability of densely populated areas for the permanent disposal of radioactive waste. Citizens stated that the EIS should conclude that waste cannot be stored in heavily populated areas and should be removed to commercial facilities in unpopulated, nonagricultural areas.

DOE response: In the RI/FS-EIS, a range of alternatives for cleanup of the St. Louis site are identified and evaluated. The combined CERCLA and NEPA process requires that a broad range of alternatives be evaluated. Alternatives ranging from the no-action alternative (consideration of which is required by NEPA) to onsite or offsite disposal of contaminated material are being evaluated.

The final cleanup alternative and the location of disposal facilities must be protective of human health and the environment. The socioeconomic impact of a given cleanup alternative will also be evaluated. The number of people in the area and the economic setting immediately around a potential site are major considerations in developing exposure estimates. Densely populated area considerations thus include increases in the risk of exposure and the impact on the local economy. Other factors, such as the amount of contaminants, potential exposure pathways, the likelihood of contaminant migration, and the suitability of alternative sites are also considered. The selection of a site must balance these multiple technical and social science factors to identify a site that meets federal CERCLA and NEPA requirements for protection of human health and the environment. For example, if onsite disposal was selected as the preferred alternative, the disposal cell would be engineered to be protective and comply with regulations, and the economic impact to the area would be fully understood.

The favored alternative will be presented to the public, the state, and EPA Region VII in a document called the proposed plan.

Shouldn't the disposal site be in a stable location away from water?

Several citizens urged that any disposal site should be far removed from water and be geologically stable. Citizens felt that any permanent disposal option should be located out of floodplains and areas of potentially high surface water runoff.

DOE response: Several disposal options and locations are carefully evaluated during the development of the FS-EIS in support of the decision-making process. Any disposal site to be built either onsite, in state, or out of state would require a site suitability study to be

performed, which would include evaluating the geologic (e.g., earthquake) and hydrologic (e.g., groundwater) conditions at the site. The facility would be built only at a location that is geologically and hydrologically suitable to meet federal requirements. Site suitability would depend on the ability to ensure containment of all stored waste. Protection of human health and environment is of foremost importance in site selection.

Are bunkers appropriate to permanently store radioactive waste?

Several comments were received on this issue. Comments were received questioning the effectiveness of bunkers as a disposal option. Some citizens found the use of bunkers to be unacceptable.

DOE response: The FS-EIS evaluates a broad range of cleanup alternatives, including a containment cell (e.g., bunker type facility). If onsite disposal is selected as a final preferred alternative, a more thorough evaluation of cell design will be performed. If the site is found to be suitable for onsite disposal, a containment cell can be designed that is protective of human health and the environment.

Why are certain cleanup alternatives being considered?

Many citizens voiced their favor or disfavor to various alternative cleanup plans, including specific references to bunker containment, out of state shipment, and in state shipment.

DOE response: CERCLA requires the evaluation of multiple cleanup alternatives. NEPA requires a systematic, interdisciplinary approach that will ensure the integrated use of natural and social sciences. In the FS-EIS, each cleanup action alternative is evaluated against CERCLA and NEPA criteria, foremost among which is the protection of human health and the environment. Both short- and long-term technical and social science effects are evaluated. Any alternative that is found to pose an unacceptable risk to human health and the environment is eliminated from consideration. The public will have a chance to comment on the cleanup alternatives, and the favored alternative will be chosen with public comments

being considered. The favored alternative is presented to the public and EPA Region VII in a document called a proposed plan. The alternative to be implemented is presented in an ROD document.

What are the specific cleanup alternatives being considered for St. Louis?

The people of St. Louis County were concerned that an alternative will be chosen that poses a continued risk to them, their families, and their community. They felt strongly that the waste, especially considering the long half-life of uranium and thorium, should be stored in a location where it does not pose a threat to large numbers of people. Some cited evidence that recent earthquakes show us that even sturdy structures are not invulnerable to nature, and some were concerned that a storage bunker at or near the airport site would not really seal waste.

DOE response: Multiple cleanup alternatives have been described in the St. Louis site document entitled *Initial Screening of Alternatives* (ISA). This document provides the information for the identification and formulation of cleanup action objectives, identifies cleanup technologies, and develops and screens the cleanup alternatives for each affected area of the St. Louis site. The ISA has been approved by EPA Region VII and MDNR. The ISA was prepared to provide regulatory agencies and the public the opportunity to review and comment on alternatives that are being considered for the cleanup of the St. Louis site.

Disposal of waste locally is only one of many disposal alternatives being considered for the St. Louis waste. A site suitability study has been performed for onsite disposal. If offsite disposal were selected as the preferred alternative, additional site suitability studies would be performed as part of the siting process. These studies would look at the structural and tectonic stability of the area, as well as other geologic and hydrogeologic conditions.

Shouldn't other professionals besides architects and engineers be used to plan disposal of radioactive waste?

A citizen voiced his belief that developing suitable storage solutions for radioactive wastes will require others besides engineers and architects. He expressed concern about the limits of their abilities.

DOE response: FUSRAP employs a team of experts in numerous professions who provide input into the overall cleanup process. Engineers and architects are just two groups of professionals providing their expertise. Scientists, environmental engineers, geologists, industrial hygienists, risk assessment experts, sociologists, and others all provide information into the series of CERCLA and NEPA documents. This diverse staff is currently identifying and evaluating the numerous criteria involved in choosing the final alternative(s).

1.5.6 Comments on Other Sites

Why are the West Lake Landfill and the Weldon Spring sites not being addressed?

Citizens urged that the wastes at the West Lake Landfill and at Weldon Spring be cleaned up along with those identified for the St. Louis site. One individual pointed out that the West Lake Landfill waste originated with the Manhattan Project and should be considered along with the other sites for cleanup. Another individual expressed concern about the proximity of the West Lake Landfill to the Missouri River. One individual asked for clarification of the number of sites under FUSRAP; were there six contaminated sites on the cleanup action list? In general, citizens wanted to know where else contamination is a problem in the state of Missouri.

DOE response: The West Lake Landfill is on the National Priorities List but is not a FUSRAP site. The cleanup of this site is covered by EPA through CERCLA. This act was designed primarily to perform cleanup of abandoned or uncontrolled hazardous waste sites. Questions regarding the types and extent of contamination will be addressed in an EPA study specific to the landfill.

The Weldon Spring site is being addressed by DOE under another program, the Weldon Spring Site Remedial Action Program. The schedule and plans for cleanup for Weldon Spring are independent of any FUSRAP activities.

The sites in St. Louis that are being addressed under FUSRAP include: (1) SLDS, (2) SLAPS, (3) SLAPS vicinity properties, and (4) the Latty Avenue properties.

Has DOE added the Hematite Uranium Fuel Fabrication Plant in Jefferson County to the FUSRAP list?

DOE response: The Hematite Uranium Fuel Fabrication Plant in Jefferson County is licensed by the Nuclear Regulatory Commission (NRC), and DOE has no authority to perform cleanup actions at this facility. Information on the site may be obtained through NRC using NRC license number SM-33, docket number 0700-0036.

Why isn't the waste taken somewhere else, like to the Callaway County Nuclear Power Plant?

Citizens suggested that St. Louis site waste should be taken from the St. Louis area and moved to a variety of locations, both in state and out of state. Others wanted the waste moved out of state, perhaps to Utah or to a federal repository. A representative of St. Louis County informed DOE that the county was establishing a commission to explore alternative disposal options for radioactive waste now stored in the St. Louis area. One individual commented that the risk of radiation precluded permanent storage in the city and county of St. Louis. Yet another encouraged DOE to come to the Missouri Congress to help find a nonurban disposal site. A local citizen offered DOE the use of his farm for construction of a bunker.

Citizens expressed concern that SLAPS has large amounts of groundwater and could experience an earthquake. Others expressed concern that SLAPS is not a safe storage site and that the waste should be moved elsewhere, such as to a nonurban area. One citizen

stated that DOE's recommendations have not worked at SLAPS and that leaching of wastes continued even after remedies were implemented.

The Callaway County Nuclear Power Plant was suggested as a possible storage and disposal site, as it already has nuclear waste. Above-ground concrete bunkers were urged for use at the Callaway site, and one individual suggested using Canadian experience with bunker design as a model. Some were curious about technical reasons for not choosing the Callaway Plant.

DOE response: DOE is required by law to consider several cleanup alternatives. In addition to disposal options within the state of Missouri, DOE is also considering several out-of-state disposal options. These include existing commercial and federal facilities, as well as a new DOE facility constructed specifically for FUSRAP waste. Each of these dispos options is being carefully evaluated in the FS-EIS. Of paramount importance is that the chosen alternative protect human health and the environment.

DOE invites input from the proposed commission and participation and comments from the public on the ongoing environmental studies. DOE will be glad to provide assistance to any group by identifying information currently available to the public for the St. Louis FUSRAP site. DOE welcomes any input the Missouri Congress would like to offer concerning site selection. DOE invites the Congress to review the FS-EIS during the public comment period. Comments will be considered in the final plan. DOE appreciates the resident's offer for use of his land, but an evaluation of the suitability of specific sites will be made only if an in-state option is selected.

The Callaway County Nuclear Power Plant is a possibility for an in-state disposal site. However, only if the in-state disposal option is selected will a technical evaluation of suitability of the Callaway site be made. This evaluation could include consideration of a containment cell (e.g., bunker) facility.

1.5.7 Comments on Public Participation in the Cleanup Process

How does the public get to participate in the FUSRAP cleanup process?

DOE response: The role of public participation in the hazardous waste cleanup process is addressed in two federal acts (CERCLA and NEPA) and their implementing regulations. In complying with these two acts, DOE has adopted the approach of integrating the CERCLA and NEPA processes as reflected in DOE Order 5400.4. These acts require that public participation be sought and incorporated into the process wherein the environmental impacts of reasonable alternative courses of action are evaluated and entered into the decision-making process. These two acts, passed by the elected representatives in the United States Congress, recognize public participation in national decisions regarding hazardous waste and major federal actions. A public meeting must be held to inform the public and to receive comments from the public for consideration during the development of the FS-EIS. Proposed cleanup alternatives must be published, and public comments must be heard. The final plan must be published before the commencement of any cleanup action. CERCLA does not provide for the public to vote on each decision regarding hazardous waste disposal.

How can I get more information about the St. Louis site?

Several participants asked where additional information on the FUSRAP St. Louis site could be obtained and asked to be included on the mailing list.

DOE response: Information that is being used to support the remediation of the St. Louis FUSRAP site is contained in the administrative record. Copies of the administrative record are available at the following locations:

Government Information Section
St. Louis Public Library
1301 Olive Street
St. Louis, MO 63103

St. Louis County Library
Prairie Commons Branch
915 Utz Lane
Hazelwood, MO 63042

DOE Public Information Center
9200 Latty Avenue
Hazelwood, MO 63042

The DOE Public Information Office on Latty Avenue in Hazelwood is also a source for free information about FUSRAP. Information on formal public meetings, workshops, and informal meetings with DOE staff members and technical support staff is published in area newspapers at least two weeks before they are held. Members of the public and representatives of organizations who wish to receive information by mail may ask to be included on a mailing list. To add your name to the mailing list, call or write:

DOE Public Information Office
9200 Latty Avenue
Hazelwood, MO 63042
(314) 524-3329

To schedule an appointment with DOE's St. Louis site manager, call or write:

U.S. Department of Energy
Former Sites Restoration Division, EW-93
P.O. Box 2001
Oak Ridge, TN 37831-8723
(615) 576-9634

In addition, a toll-free telephone line has been established for FUSRAP: 1-800-253-9759.

How can we participate more directly in the decision-making process?

Citizens expressed interest in becoming involved in the process of evaluating alternatives, including formation of a citizen advisory panel. Formation of an independent

technical oversight body [such as that at the Waste Isolation Pilot Plant (WIPP)] was also mentioned.

DOE response: DOE invites and encourages public participation and comment on the cleanup alternative selection process. Participating in the workshops, public meetings, and discussions and correspondence with project staff members are important ways to stay involved in the decisions. The review of planning documents is also encouraged, as they become available. DOE would also be glad to provide information, technical support, and limited resources for a citizen advisory panel or board that is formed to participate in selecting cleanup alternatives for a FUSRAP site.

DOE is familiar with the Environmental Evaluation Group that is overseeing the WIPP project. DOE is currently reviewing the feasibility of developing a FUSRAP technical review group. DOE values public input and encourages participation in meetings and comments on the ongoing environmental studies and alternative selection process.

At the national level, DOE prepared a draft of the implementation plan (January 1992) for its PEIS for the Environmental Restoration and Waste Management Program. The implementation plan was prepared to record the scoping process results, report identified issues and issue disposition, and describe the proposed action alternatives and analytical methodologies. To request a copy of the implementation plan, write to:

U.S. Department of Energy
Attention: Glen L. Sjoblom
Environmental Restoration and Waste Management, EM-1
1000 Independence Ave., SW
Washington, DC 20585

Does DOE encourage local government involvement?

DOE response: DOE encourages local government participation in exploring and developing effective alternatives for the site remediation. In accordance with DOE policy to integrate CERCLA requirements with NEPA values, DOE will provide information and technical

assistance to government organizations and other groups that wish to give input into the RI/FS-EIS and ROD decision-making process. These organizations and the public are also encouraged to review and offer comments on DOE's studies, plans, and initiatives.

Why doesn't DOE implement the St. Louis public's wishes and remove the waste from St. Louis?

Participants noted that the issue of radioactive waste disposal was included in a 1991 local referendum, with an overwhelming majority voting in favor of waste removal to a DOE site away from the St. Louis populace. The St. Louis Board of Aldermen submitted material on their position. Comments were also received from state and local elected officials. It was noted that St. Louis County is establishing a commission to explore alternative disposal options for radioactive waste.

DOE response: Consideration of community input through such channels as recommendations and referendums is only one requirement in the RI/FS-EIS process. Other requirements include overall protection of human health and the environment, cost, long-term effectiveness and permanence, implementability, environmental impacts, socioeconomic issues, and cumulative impacts. Consideration of all requirements is mandated by CERCLA and NEPA as part of the implementation of removing the waste from St. Louis.

Is landowner permission needed for DOE to go onto private property?

Citizens asked if the public will be informed before cleanup work begins and who in the city government will be notified. Requests to be notified were also made.

DOE response: Access agreements are completed with property owners, both commercial and residential, before DOE contractors go onto property to take samples or remove contamination. In addition, DOE publishes newspaper notices of important steps in the process of reaching a decision on the cleanup methods to be used for contaminated properties. The public is encouraged to review and offer comments on the proposed alternatives.

How can we trust DOE now?

Several citizens suggested that DOE had kept facts secret in past interactions with the public or had not provided accurate information. Others questioned the validity of research in progress. Many of the concerned citizens felt that DOE has a credibility problem. The perception exists that there is associated with DOE a history of distortions, coverups, and failure to acknowledge the professional scientific opinion of those who are against nuclear power. They felt that the government needs to be more honest about waste issues. Some expressed concern that the cleanup may not occur.

DOE response: Initial activities at MED sites were conducted in secrecy for national security reasons. As was characteristic of the time, early scientists lacked knowledge about the full impact of environmental contamination. Not all of the waste management practices considered safe and prudent at the time have proven effective. Recognizing the importance of public involvement, full accountability and open communications, the secretary of energy announced a 10-point initiative in June 1989. A five-year plan was developed with input from federal and private parties and is being implemented. The effect of the resulting cultural change has been to shift DOE's emphasis from a national defense mission to a mission of environmental consciousness. Open communication is encouraged in current DOE operations.

Other changes have occurred over the years. The passing of environmental acts such as CERCLA and NEPA has resulted in more available public information. These laws incorporate a system of documents that will provide the information for selection of a final alternative. These documents are published for public comment, and input received from the public is included as one of nine evaluation criteria used to select a cleanup alternative for the site. Regulatory agencies will also provide input and oversight throughout the cleanup action process. With respect to the cleanup occurring, the CERCLA legislation and associated laws mandate that FUSRAP sites be remediated.

1.5.8 Comments on Economic Issues

Will DOE studies address economic impacts on properties adjacent to future storage sites?

The economic impact, to both the neighborhood and the region, of onsite or in-state disposal was raised as an issue in disposal site selection.

DOE response: The economic impact of a permanent disposal facility, including adjacent property, is addressed in the FS component of the RI/FS-EIS. Socioeconomics and the impact to land use are two criteria of NEPA that address economic impact. Alternative disposal areas are addressed for both in-state and out-of-state locations in the FS component of the RI/FS-EIS.

Does DOE offer indemnification to owners of potentially contaminated property?

Citizens asked if current property owners who sell land that is contaminated from past DOE activities could face any legal liabilities.

DOE response: Regardless of ownership of the property, liability for the cleanup of contamination from past DOE activities rests with DOE. The sale or transfer of property will be handled in accordance with CERCLA 120 (h).

Who will pay for removing contamination from a FUSRAP site?

Citizens raised issues about who would bear the cost of cleanup. They said they believe that a city should assume no cost.

DOE response: The cost of remediation at sites under the authority of FUSRAP will be borne by DOE and by other parties who are determined to be responsible for the contamination.

Will DOE make sure that cleanup money is spent wisely?

Citizens expressed the view that cost efficiency in FUSRAP was an important issue. Citizens stated the position that storing waste at a FUSRAP site would not be cost-effective. Another suggested that siting a storage or disposal site in a nonurban area would be less costly.

DOE response: DOE is concerned with spending taxpayer money wisely and responsibly. Cost is just one of the criteria used to evaluate alternatives in the FS component of the RI/FS-EIS. A balanced weighing of the criteria will be used to select the final alternative. In the FS component of the RI/FS-EIS, each cleanup alternative, such as storage or disposal, is evaluated against many criteria, one of which is cost. If two alternatives were found to be equally effective and implementable, the less expensive alternative would be selected.

What is DOE's responsibility to nearby property owners for economic impacts they might incur?

DOE response: DOE is not authorized to compensate property owners for economic hardships resulting from either the presence or the removal of contamination from their property or a nearby property. DOE can only compensate property owners for personal property that must be removed or disposed of to complete the cleanup and cannot be replaced by DOE with an item of equal value (e.g., a tree or shrub located in a contaminated area). Other personal property such as fences and driveways that must be removed during cleanup will be repaired or replaced in kind. Although the location of contamination on the privately owned properties in St. Louis makes it highly unlikely, DOE is also authorized to compensate property owners or occupants for living expenses if they are required to be displaced during cleanup. DOE will work with property owners as much as practicable to schedule cleanup to minimize any impacts.

1.5.9 Comments on Land-Use Issues

Does DOE have a policy that restricts the sale of potentially contaminated property before cleanup?

Concerns focused on whether there are protocols that will impede property transfer.

DOE response: No, DOE has no control over the transfer of property that has been found to be contaminated.

When will the Berkeley Khoury ball fields be returned for public use?

Citizens raised a range of issues on access to the Berkeley Khoury League ball fields.

DOE response: DOE has "standards" or guidelines for radioactive contamination in soil that are adopted from EPA guidelines. If soil contamination exceeds these guidelines, cleanup action is considered. On a site-specific basis, contamination levels above DOE guidelines are reviewed to determine if there is any practicable way for the contamination to reach the human environment in sufficient quantity to present a potential health hazard. If such a hazard exists, then action is taken immediately. However, if it is determined that there are no significant health risks, site cleanup is scheduled accordingly.

In October of 1986, samples were taken from the recreation fields in the area extending about 90 m (300 ft) north of McDonnell Boulevard. Analysis of these samples found that contamination exceeding DOE soil contamination guidelines was present.

Utilizing these data, a conservative hazard analysis was performed on the recreation fields. This analysis made conservative assumptions on conditions that are not normally present, such as continuous high levels of dust containing radioactivity. Also, all of the contamination was found in grass-covered areas, which further reduces the risk of exposure to ball players by means of ingestion or inhalation. The results of this hazard assessment show that a ball player will receive a maximum radiation dose of 13.2 mrem per ball season,

which is below the dose the public receives from naturally occurring radiation in the earth, building materials, and the atmosphere. Natural background radiation levels have been estimated to be approximately 100-150 mrem per year. Based on this analysis, DOE has concluded that continued use of the recreation fields presents a level of risk well below the standards for the public.

To obtain additional information, more soil samples were taken in November 1987, including 26 samples from the infield areas of the ball fields. No areas of contamination above the DOE soil contamination guidelines were found in the infields. This survey was consistent with data collected in 1986 for other areas of the recreation fields.

These data were provided to the City of Berkeley and the Airport Authority in March 1987 and were reported in the St. Louis Post-Dispatch on April 9 and 17 and June 18 of 1987.

1.5.10 Comments on Transportation Issues

How can you assure the residents in the community that soil transportation methods will be safe?

Several people were concerned that loading, transport, and unloading operations could spread contaminated soil or put dust into the air. They asked what type of trucks would be used and whether special containers would be used.

DOE response: DOE will use a trucking firm that specializes in moving radioactive/hazardous waste material. These trucks will use measures such as tarps and liners that seal in the soil and prevent loss. In addition, the soil will be kept damp to ensure that airborne particulates are not released, especially during loading, transport, and unloading. Surveys will be performed when trucks leave the site and when they reach their destinations to ensure that no soil escapes. Similar transport operations at other sites have successfully moved contaminated materials short distances in trucks with liners and tarps, without the use of special containers.

Will St. Louis homeowners along the haul routes be evacuated while their properties are being cleaned up?

Private homeowners were interested in whether they would be required to leave their properties during cleanup activities. Some were concerned as to how far away from the old truck routes contamination might extend.

DOE response: There should be no need to evacuate homeowners during the removal action. Most of the contamination in the soil at residential properties is in the ditches along the roadways, which should be capable of being removed without evacuating residents.

Property owners would be notified of any removal actions by DOE. The public will be notified of any removal actions for the vicinity properties through media releases. Notification to public utilities, emergency response organizations, and city municipal offices will be made before the removal actions start.

Why did contamination occur along old St. Louis transport routes?

DOE response: During initial waste removal operations in the mid-1960s, ore residues were transported from SLAPS to the Latty Avenue properties. The trucks used at that time were basically open-bed trucks with few precautions for preventing dust and small amounts of residue from blowing off the trucks and contaminating properties by the roadway. The Berkeley Khoury ball fields became contaminated when materials blew from open piles at SLAPS. Erosion later caused contaminated soil to enter Coldwater Creek.

1.5.11 Comments on Extent of Contamination

How well are the areas of contamination defined?

Several citizens were concerned that boundaries of contaminated areas might be larger than currently estimated.

DOE response: Cleanup investigations are conducted to identify the extent of contamination at all locations composing a given FUSRAP site. An environmental monitoring program designed to identify any contaminant migration is put in place also. If new information is found indicating that current boundaries of contamination are ambiguous, the need for additional sampling is evaluated, and additional sampling is implemented if deemed appropriate.

Is it possible there are unidentified contaminated St. Louis properties?

Several citizens expressed concern that their properties might be affected by contamination that has not been detected in sampling so far.

DOE response: DOE has acted upon requests for property sampling. An RI was conducted to identify the extent of contamination at all locations composing the St. Louis site. Sampling included all properties—residential, commercial, and municipal—that were known to contain possible contamination. The extent of contamination was defined in regard to both vertical and horizontal boundaries with an appropriate level of confidence. The characterization included both random and bias sampling. Random sampling would detect contamination not yet found in sampling so far. Pathways analysis, to evaluate the paths contamination can take, was also performed.

If new information comes to light that a potentially contaminated property under FUSRAP jurisdiction may exist, or if information on the boundaries of contamination is found to be ambiguous, additional investigations would be conducted.

How significant are the levels of contamination at the St. Louis site?

Several citizens noted that soil samples at the St. Louis site show radioactivity above that which occurs in nature. They were concerned that these levels might be dangerous to the public or threatened and endangered species. Some asked how these levels related to "normal" or background levels.

DOE response: Samples taken at the St. Louis site are typically analyzed for four radioactive isotopes including thorium (Th-230, Th-232), radium (Ra-226), and uranium (U-238). These four isotopes and their radioactive decay products compose the main radionuclides that are present at the St. Louis site. Although there are a few areas where soil contamination levels fall within the thousands of pCi/g range, most soils have activity levels in the tens and hundreds of pCi/g range. The soil average natural background concentrations for Th-230, Th-232, and U-238 in the St. Louis area are about 1.3 pCi/g, 1.1 pCi/g, and 1.1 pCi/g, respectively. The baseline risk assessment for the St. Louis site was performed in accordance with EPA's guidance for human health and ecological evaluation at hazardous waste sites. The risk assessment shows that, under current land use conditions, existing levels of contamination are within EPA's target range and therefore pose no unacceptable threat to the public and surrounding environment.

What is the volume of contaminated soil at the St. Louis site?

DOE response: The volume of soil at all the St. Louis site locations, which contains radioactivity in excess of the DOE cleanup guidelines, is currently estimated at 635,000 m^3 (830,000 yd^3). These guidelines require that the top six inches of soil will not exceed 5 pCi/g, and any soil beneath six inches will not exceed 15 pCi/g, for thorium and radium. The DOE-calculated cleanup guidelines developed for total uranium and uranium-238 are 100 pCi/g and 50 pCi/g, respectively.

How much groundwater contamination is there at the St. Louis site?

Local citizens were concerned about the quality of their groundwater and feel they should be informed of sampling results.

DOE response: Wells at SLAPS, the ball fields, and HISS show basically background radioactivity levels, with some areas having slightly elevated levels. Several wells on the west side of SLAPS show elevated thorium levels. Groundwater at SLDS is still being characterized. The current data show the deep aquifer to have only background radioactivity

levels. A sample from one of the shallow wells at SLDS shows slightly elevated levels of uranium.

How extensive was the sampling at SLAPS itself, around runways, etc.?

DOE response: Extensive surveys have been conducted around SLAPS, first by sampling areas known to be contaminated and then working out from there until clean areas were identified. At SLAPS, field sampling activities included gamma walkover surveying (e.g., scanning the ground surface with a hand-held gamma detector), collecting shallow and deep soil samples, installing and sampling numerous groundwater monitoring wells, and collecting surface water and sediment samples from Coldwater Creek. The walkover surveying and soil sampling show the deep soil contamination to be concentrated at SLAPS. Shallow contamination extends north to the ball fields and just south of Banshee Road. No contamination has been identified on the Lambert-St. Louis Airport property.

Is our drinking water in the area safe from St. Louis site contamination?

Many St. Louis citizens inquired about the possibility that radioactive waste is contaminating the local drinking water. The sites that were of most concern were SLAPS and the Latty Avenue properties, which are near Coldwater Creek, which in turn feeds into the Missouri River upstream of the Chain of Rocks municipal water intake. There was concern that instrumentation is not being used that could detect alpha radiation in the sediment or water.

DOE response: Gross alpha measurements of the water taken from the Chain of Rocks intake show that the radioactive material content is within background levels. Samples are taken at least quarterly by DOE, by City of St. Louis drinking-water-supply personnel, and by the State of Missouri. The federal Safe Drinking Water Act requires screening of public water supplies for alpha radiation.

Laboratory analysis is performed on water and soil samples using specified methods that utilize sensitive instrumentation that can detect alpha radiation.

Is residual contamination from SLAPS contaminating surface water?

Citizens asked whether contaminants from SLAPS are contaminating surface waters adjacent to the airport. One individual asked whether DOE claimed that all of the contamination had been removed. Another person was concerned that contaminated soil that had been cleaned up from outside the fence at SLAPS had been placed back onsite.

DOE response: Remedial investigations performed along Coldwater Creek identified radioactive contamination in sediments along portions of the creek. However, no radioactive contamination has been identified in the surface water.

The contaminated sediment in the creek has not been cleaned up, to date. However, risk analyses indicate that, in the creek's present status, there is no unacceptable threat to public health and the environment. Contamination from HISS and SLAPS has been identified as a significant contributor to the contamination of the Coldwater Creek sediments.

To control further migration of contaminants from these sites, gabion walls (reinforced rock walls) along Coldwater Creek at SLAPS and pile covers at HISS have been used. An environmental monitoring program is in place that routinely monitors surface water.

In regard to the placement of contaminated soil back within the airport site fence, a small amount of soil was cleaned up from outside the fence at SLAPS and placed inside the fenced area. This was done as a means of controlling exposure to the public. Fences and signs are common institutional control methods used to reduce the public's direct exposure to contaminated soil.

Are locally caught fish contaminated with radiation?

Citizens asked whether fish are accumulating radioactive contaminants in their tissues through a process called bioaccumulation, and whether such fish are safe to eat.

DOE response: No evidence of bioaccumulation has been found, but the data are insufficient to rule the possibility out entirely. Given the remote possibility of bioaccumulation of radioactive contaminants and the large range of industrial pollution sources on Coldwater Creek, DOE recommends that fish taken from Coldwater Creek not be eaten by the public.

1.5.12 Comments on Data Quality and Sufficiency

What are you doing to make sure you aren't missing important information about what needs to be done?

DOE response: The FS-EIS process includes evaluating the alternatives using information obtained from numerous sources. Sources include data from characterization activities, previous scientific studies by both DOE and other organizations, as well as local agencies that can provide information on socioeconomics, land use, population, etc. Public participation, in the form of comments on the ongoing environmental studies, is another source of information. As the results of the contamination determinations from the RI process and information received from other parties are applied to evaluating cleanup alternatives, the need for new data or information is evaluated. The final alternative chosen for site cleanup implementation will be decided based on this multifaceted set of information.

Why is further sampling needed at the St. Louis site?

In previous St. Louis public hearings, DOE speakers acknowledged that previous sampling results showed areas where more information was needed. This is common with environmental surveys. Some residents were concerned about these data gaps.

DOE response: Additional types of data are to be collected to fill gaps identified in a detailed study of data acquired during activities described in the work plan (March 1991) and based on comments received from EPA while preparing the RI report. Objectives have been identified to provide the type of data required to more precisely define contaminant boundaries and to provide additional characterization and background information. These

data will supplement existing information to allow refining evaluation of cleanup action options.

Will the cleanup studies go beyond the current priorities described in the DOE St. Louis five-year plan?

Several commenters stated their desire for the RI/FS-EIS to cover such contingencies as potential pathways of exposure in the event of a water main rupture, and air quality.

DOE response: The baseline risk assessment addressed potential pathways of exposure that could cause potential risks to human health and the environment. The FS-EIS will address air, soil, and water quality during the evaluation of alternatives. DOE will consider expanding the priorities set in the five-year plan as deemed appropriate in formulating the PEIS implementation plan. DOE appreciates suggestions and comments regarding these studies.

1.5.13 Lists of Citizens Who Commented

A list of the speakers at the public meeting in the order of their appearance at the meeting is presented in Table 1-3. Table 1-4 lists the names of people submitting their comments by letter.

FIGURES FOR SECTION 1.0

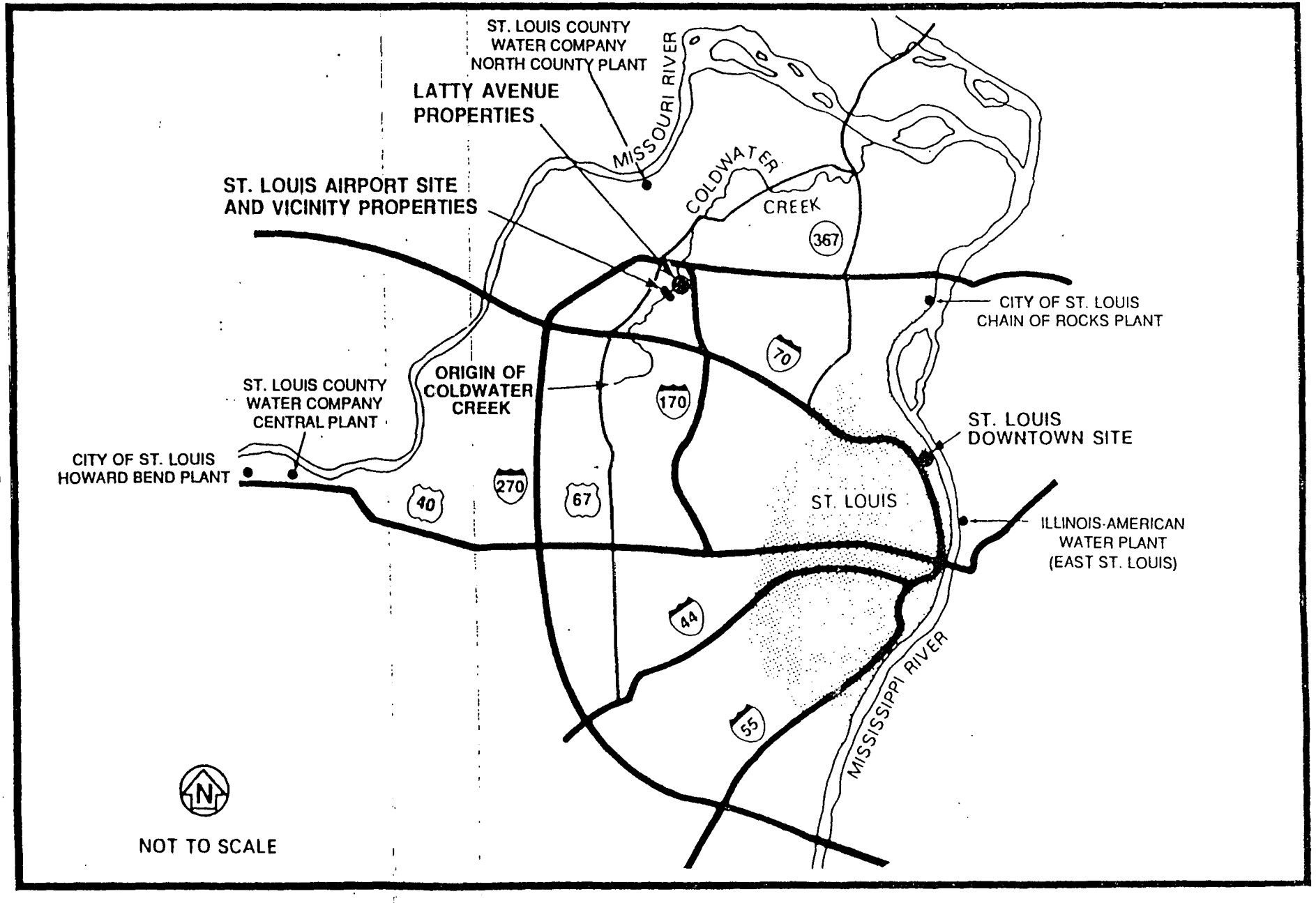


FIGURE 1-1 LOCATIONS OF FUSRAP PROPERTIES IN THE ST. LOUIS, MISSOURI, AREA

FIGURE 1-2 GRAPH OF PUBLIC COMMENTS BY KEY SUBJECT AREA

TABLES FOR SECTION 1.0

Table 1-1

Overview of the Nature of the Public Comments

Key Subject Areas	Number of Comments
1. Schedule and Pace of Cleanup	Total 35
- Long timetable for environmental cleanup	13
- Movement of date of ROD forward	9
- DOE personnel changes affecting schedule	2
- Priority of cleanup of sites	2
- Consideration of additional alternatives for cleanup	8
- Public notification of cleanup actions	1
2. Safety and Health Concerns	Total 55
- Efforts to safeguard public from areas of known contamination	7
- No warning signs posted at sites	4
- Risk associated with cleanup activities	15
- Worker safety during cleanup	4
- Radiation exposure risk in Building 116 of Mallinckrodt chemical Works	3
- Dispersion of contaminants along old haul routes by normal activities	2
- Determination of risk associated with low-level radiation	13
- Methodology of radiation measurements	4
- Health effects of radiation exposure	3
3. Interim Cleanup Measures	Total 11
- Temporary vs. permanent storage	5
- Decontamination/disposal of buildings	2
- Public safety during interim activities	4
4. Storage and Disposal Site Selection	Total 79
- Permanent storage concerns	
a. Near populated areas	32
b. Away from water supplies	15
c. Geological stability	8
d. Use of bunkers	15
- Alternatives considerations	8
- Use of varied professionals	1
5. Other Sites	Total 35
- Cleanup of non-FUSRAP sites	
a. West Lake Landfill	14
b. Weldon Spring	3
c. Hematite Uranium Fuel Fabrication Plant	1
- Use of Callaway County Nuclear Power Plant	17

Table 1-1

(continued)

Key Subject Areas	Number of Comments
6. Public Participation in Cleanup Process	Total 33
- Public participation process	3
- Site information availability to the public	5
- Formation of independent technical oversite committee	2
- Local government involvement	3
- DOE response to November 1991 referendum	4
- Private property access by DOE	2
- Public trust of DOE	14
7. Economic Issues	Total 16
- Impact to property values adjacent to future storage sites	2
- Financial liability of past/present owners of potentially contaminated property	1
- Responsibility of financing cleanup activities	1
- Cost efficiency of DOE	8
- DOE's responsibility to nearby property owners	4
8. Land-Use Issues	Total 6
- Zoning to restrict transfer of potentially contaminated property	1
- Release for public use of Berkeley Khourg ball fields	5
9. Transportation Issues	Total 7
- Safety associated with transportation of contaminated soil	5
- Origination and extent of contamination along old haul roads	2
10. Extent of Contamination	Total 16
- Areal extent of contamination	2
- Significance of levels of contamination	3
- Volume of contamination	2
- Extent of groundwater contamination	1
- Extent of sampling performed at SLAPS	1
- Safety of drinking water	5
- Contamination of surface water	1
- Risk in consumption of fish	1
11. Data Quality and Sufficiency	Total 7
- Sufficiency of characterization to evaluate alternatives	6
- Continuation of studies beyond current St. Louis five-year plan	

Table 1-2

FUSRAP St. Louis Site Schedule

Document	Issue Date
Field sampling plan	November 1992
Remedial investigation report	January 1994
Baseline risk assessment	January 1994
Initial screening of alternatives	January 1994
Feasibility study component of RI/FS-EIS	January 1994
Proposed plan	January 1994
Record of decision	April 1995

NOTE: The RI/FS-EIS consists of the remedial investigation report, baseline risk assessment, feasibility study, and proposed plan.

Table 1-3

Participants at the Public Meeting Held on January 28, 1992

Speakers
Lee Brotherton, Special Assistant to St. Louis City Executive Buzz Westfall
Joan Bray, District Director for Congresswoman Joan Kelly Horn
Roy Temple, Representative of Lieutenant Governor Mel Carnahan
Mike Reid, State Representative, 75th District
John Shear, Chairman, St. Louis City Council,
Bill Miller, Mayor of Berkeley
Ted Hoskins, Berkeley City Councilman
Jeannett Eberlin, Representative of Hazelwood City Council, and David Hale, State Representative
Molly Rickey, Hazelwood City Councilwoman and Mayor Pro-Tem
Dan McGuire, Alderman from 28th Ward in the City of St. Louis
Henry Royal, Physician at Washington University School of Medicine
Byron Clemmons
Phil Baker
Marvin Pion
Laura Barrett, Director of MOPER (state-wide consumer environmental group)
Frank Reis
Nancy Lubiewski
Martin Buchleit
Mary Dreyer
Tammy Shea
Lewis Green
Virginia Harris
Kay Drey
Germaine O'Donnell
Bud Derops

Table 1-3

(continued)

Speakers
Gilda Evans
Daniel Reed
Lorraine M. Battan, Berkeley City Clerk
William Dickoff
Rosemary Davison
Gavin Perry, Washington University Medical School
Spring Cech
Debra Wilson, speaking for Kathy Lewis and herself
Ed Mahr
Rochelle Morrison
Michael O'Brien
Ann Kennedy
David Arnold

Table 1-4

Citizens Commenting by Letter

Citizens
Maureen Baker
Daniel Bender, Co-President, Students Making A Real Tomorrow (SMART)
Herman T. Blumenthal, Ph.D., M.D.
John Brill, Organization for Black Struggle
Jutta Z. Buder
Louise Cassilly Bullock, Interfaith Committee on Latin America
Michael Burke
Maryse Carlin
Mel Carnahan, Missouri Lieutenant Governor
Beatrice Buder Clemens
Byron Clemmons
Rosemary Davidson, Chairperson, Commission on Human Rights - St. Louis Archdiocese
Leon Deraps
Sandra Dow
Kay Drey
Tim Dunn
Gretchen Felix
Larry Felkner, D.D.S.
Rev. Deborah G. Fortel
John Gestrich
Anna Ginsberg, Executive Director, St. Louis Committee for a Nuclear Weapon Freeze
Lewis C. Green, Attorney, Missouri Coalition for the Environment
Louise Green
Roberta Gutwein
Joy Guze
Mary Halliday, Vice President, St. Charles Countians Against Hazardous Waste
Deborah Hamilton, Assistant City Manager, City of Berkeley

Table 1-4

(continued)

Citizens

Virginia Harris

Margaret Hermes

Sister Susan Jordan, SSND, Coordinator, Midwest Coalition for Responsible Investment

Wendy Katz

Debra Koenig, Citizens Against a Radioactive Environment

Paul Kranzberg

Marilyn Lanson

Kathy Lewis

Rachel Locke

Yvonne Logan, Bi-State Coalition on Economic Priorities

Maria Massey

Judith Medoff, Ph.D.

Peggy Meyer, Councilwoman, City of Bridgeton

Neil Molloy, 81st District, Missouri House of Representatives

Robert P. Morgan, Ph.D.

Lew Moye, President, Coalition of Black Trade Unionists, St. Louis Chapter

Gavin Perry, Ph.D.

Gertrude Faust Potthoff

Bill Ramsey, Program Facilitator, American Friends Service Committee (St. Louis Office)

Bernard C. Randolph, M.D., President, St. Louis Council on Environmental Health and Safety

Daniel Reed, Bridgeton Air Defense

Mollie Rickey, Councilwoman, City of Hazelwood

Daniel Romano

Mary Ross, Alderman, 5th Ward, City of St. Louis

Arlene Sandler

Alice Sanvito

Tammy Shea

Table 1-4

(continued)

Citizens

John R. Shear, St. Louis County Council

Robert Skrainka

Eldora Spielberg, President, Women's International League for Peace and Freedom (St. Louis Branch)

Mira Tanna

Emily Ullman

Blake Vaughan, Co-President, SMART

William Vaughan, Ph.D.

Ralph E. Wafer

Buzz Westfall, St. Louis County Executive-Elect

Joan E. Wilder

Terri Williams

Debra Wilson

Mary Wright, Director, Campaign for Human Development-Archdiocese of St. Louis

Phylis Young, Alderman, 7th Ward, City of St. Louis

2.0 SITE BACKGROUND AND SETTING

The history of site operations and disposal practices, physical characteristics of the site (including vicinity properties that may require remediation), land use, and environmental setting are provided in Subsections 2.1 through 2.3. The nature and extent of contamination is discussed in Subsection 2.4; interim response actions conducted to date are summarized in Subsection 2.5.

2.1 GENERAL SITE DESCRIPTION

2.1.1 St. Louis Downtown Site and Vicinity Properties

SLDS is in an industrialized area on the eastern border of St. Louis, about 90 m (300 ft) west of the Mississippi River and approximately 17.7 km (11 mi) southeast of SLAPS. SLDS, presently owned by Mallinckrodt, Inc., is an operating plant producing various chemical products. The property encompasses approximately 18.2 ha (45 acres) and includes numerous buildings and facilities (Figure 2-1). SLDS is traversed by tracks of three railroad lines, and several spurs service the property from the main lines. The property is fenced, and Mallinckrodt security is maintained 24 hours per day. Although not part of the property referred to as SLDS, there are six associated vicinity properties used for industrial and commercial operations (see Figure 2-2).

Water runoff is controlled by a system of combined sewers that direct excess flow to the Mississippi River. The property has an extensive network of utility lines both above and below grade. Below-grade utilities include sewer, sprinkler, water, telephone, electric, plant process piping, and natural gas lines. Overhead utilities include electric and telephone wires and plant process piping.

2.1.2 St. Louis Airport Site and Vicinity Properties

SLAPS is in St. Louis County, approximately 24 km (15 mi) from downtown St. Louis and immediately north of the Lambert-St. Louis International Airport. SLAPS is bounded by

the Norfolk and Western Railroad and Banshee Road on the south, Coldwater Creek on the west, and McDonnell Boulevard and adjacent recreational fields on the north and east. The property covers 8.8 ha (21.7 acres) and is enclosed by security fencing. Land uses adjacent to the property are varied. Because of its proximity to the airport, more than two-thirds of the land within a half-mile radius of the property is used for transportation-related purposes. The remaining land in the immediate vicinity is primarily commercial and recreational. Current uses of land are more thoroughly described in Subsection 2.3.6. There are no permanent buildings or facilities remaining at SLAPS; these were demolished and buried onsite under 0.3 to 1 m (1 to 3 ft) of clean material in 1969. Additional fill material and rubble were placed at SLAPS in 1971, 1977, and 1978. The property is grassy, with a slight incline from the east. Maintenance and surveillance, including environmental monitoring, are the only activities currently taking place at SLAPS.

No utility lines are associated with SLAPS. A water main crosses the northwestern corner and runs parallel to the property on the north. A small onsite line connected to the water main supplies a trailer used as storage space. There are no sewer lines on the property, and the trailer is serviced by a holding tank.

SLAPS vicinity properties include Coldwater Creek to the west and its vicinity properties, adjacent ball fields to the north and east, Norfolk and Western Railroad properties, Banshee Road to the south, ditches to the north and south, and the St. Louis Airport Authority property to the south. Also included are the haul roads: McDonnell Boulevard, Pershall Road [1.8 km (1.1 mi) north of SLAPS], Hazelwood Avenue [1.3 km (0.8 mi) northeast of SLAPS], Eva Avenue, Frost Avenue, and vicinity properties. These haul roads are believed to have been used during waste transfer among the properties. The haul road vicinity properties include 67 commercial, industrial, and residential properties located immediately adjacent to the haul roads. Figure 2-3 shows the locations of SLAPS and its vicinity properties.

2.1.3 Latty Avenue and Vicinity Properties

The Latty Avenue Properties at 9200 Latty Avenue include HISS on the eastern half and Futura Coatings on the western half. These properties cover a 4.5-ha (11-acre) tract in the city limits of Hazelwood and are approximately 3.2 km (2 mi) northeast of the control tower of the Lambert—St. Louis International Airport. The six Latty Avenue vicinity properties are adjacent to Latty Avenue and HISS; some are within the corporate limits of the City of Berkeley. HISS is a fairly level [elevation ranges from 157 to 159 m (514 to 522 ft)] grassy area containing two stockpiles of contaminated soil and debris in interim storage, access roads, a vehicle decontamination facility, a 12- by 12-ft office trailer, and a 24- by 56-ft public information trailer. Maintenance and surveillance, including environmental monitoring, currently take place at HISS. In 1977, while preparing the western portion of the property for commercial use, the present owner demolished one building, excavated several areas to level the property, paved several areas, and erected a number of new buildings. The material excavated was placed in interim storage at HISS. A chain-link fence completely surrounds both properties. Figures 2-3 and 2-4 show the locations and current configurations of the Latty Avenue Properties.

The Latty Avenue Properties are zoned for industrial use, and the surrounding area is primarily industrial and commercial. Stormwater runoff flows offsite into ditches that drain into Coldwater Creek. The property is served by city water and electricity, with overhead electric and telephone lines, and by underground gas and sanitary sewer lines extending to the Futura buildings; however, there are no sanitary sewer lines to HISS, and the facilities are serviced with holding tanks. Storm sewer lines run along the eastern boundary of the property.

The vicinity properties are relatively level and have been developed with commercial buildings, paved parking lots, and open, grassy areas fronting the length of Latty Avenue. Figure 2-4 also shows relative sizes of the Latty Avenue vicinity properties.

Additional details regarding SLDS, SLAPS, Latty Avenue Properties, and their respective vicinity properties are presented in Table 2-1.

2.2 SITE HISTORY

2.2.1 St. Louis Downtown Site and Vicinity Properties

From 1942 to 1957, the former Mallinckrodt Chemical Works performed work at SLDS (Figure 2-1) under contracts with MED and AEC. Several operations were performed, including process development and production of various forms of uranium compounds and metal, and recovery of uranium metal from residues and scrap (Mason 1977).

From 1942 to 1945, MED/AEC activities were carried out in areas designated as Plants 1 and 2 and in the original Plant 4 (now Plant 10). In 1946 manufacturing of uranium dioxide from pitchblende ore began at the newly constructed Plant 6. Uranium ore was digested in acid and filtered to form uranyl nitrate. A solvent extraction procedure and denitration were used to form uranium oxide. Fluorination with hydrofluoric acid was then initiated to create uranium tetrafluoride, which subsequently led to the production of uranium metal. Plant 6 operations ended in 1954. The pitchblende and radium equipment remained in place until AEC decontaminated the plant in 1958 (Mason 1977).

From 1948 through 1950, decontamination activities were conducted and supervised by Mallinckrodt personnel at Plants 1 and 2. These decontamination efforts were conducted to meet AEC criteria in effect at that time, and the plants were released in 1951 for use without radiological restrictions (Mason 1977). During 1950 and 1951, operations began at Plants 6E and 7. The original Plant 4 (now Plant 10) was modified and used as a metallurgical pilot plant for processing uranium metal until it was closed in 1956. AEC operations in Plant 6E ended in 1957, and AEC managed the decontamination efforts in Plants 4 and 6E, returning them to Mallinckrodt for use without radiological restrictions in 1962 (Mason 1977). Contaminated buildings, equipment, and soils from Plants 4 and 6E were removed. Some buildings that existed in 1962 have since been razed, and some new buildings have been constructed at the former locations of Plants 4 and 6. Plant 7 was used for storing reactor cores, removing metallic uranium from salt by a wet grinding/mill flotation process, and continuous processing of green salt (uranium tetrafluoride) beginning in 1951 (Mason 1977).

Plant 7 closed in 1957 and was released for use with no radiological restrictions in 1962 following decontamination. Plant 7 is now used primarily for storage.

In 1977 ORNL conducted a radiological survey of portions of SLDS at the request of DOE (ORNL 1981). Results of this survey showed surface alpha and beta-gamma radiation levels and radionuclide concentrations in soil in excess of limits for release of the property for use without radiological restrictions. Elevated external gamma radiation levels were measured at some outdoor locations and in some of the buildings.

Subsequent SLDS characterization activities showed that radioactive contamination could be present on six adjacent properties. Although historical information does not indicate whether these properties were used for MED/AEC activities conducted at SLDS, such use was possible. Radiological surveys of the vicinity properties were conducted by BNI in 1988 and 1990.

2.2.2 St. Louis Airport Site and Vicinity Properties

SLAPS was acquired by MED in 1946. From 1946 until 1966, the property was used to store residues (uranium-bearing material generated as a by-product of uranium processing) from SLDS. The residues were transported from SLDS to SLAPS by rail and by truck, possibly along the roads now called the haul roads. In 1966 the wastes were purchased by the Continental Mining and Milling Company, removed from SLAPS, and placed in storage at 9200 Latty Avenue under NRC license. Figure 2-5 shows approximate areas of storage for various residues and wastes. There were ten areas containing pitchblende raffinate, raffinate, barium sulfate cake, uranium tailings, metal scrap, storage barrels, and dolomite slag.

In an agreement between the U.S. Government and the St. Louis Airport Authority and at the request of the City of St. Louis, ownership of SLAPS was transferred in 1973 by quitclaim deed from AEC to the St. Louis Airport Authority. The EWDAA of 1985 authorized DOE to reacquire the property from the city for use as a permanent disposal site.

Radioactive contamination of the SLAPS vicinity properties may have been caused by runoff from SLAPS or by spillage during transport of residues from SLDS to SLAPS and from SLAPS to Latty Avenue. Railroad cars may have been used to transport wastes to and from SLAPS, and material from these cars could have spilled onto the railroad property and migrated onto adjacent properties. In addition, road and underground utility improvement activities have resulted in dispersion of contaminants to adjacent land.

The ball field property was used by the St. Louis Airport Authority as a disposal area for construction wastes during construction activities at the airport. This waste and debris have no connection with MED/AEC work; records indicate that wood debris was burned and buried at the ball field area.

2.2.3 Latty Avenue and Vicinity Properties

The residues transferred from SLAPS to the Latty Avenue Properties in 1966 included 11.8 metric tonnes (13 tons) of uranium and 29,500 metric tonnes (32,500 tons) of leached barium sulfate containing about 6.3 metric tonnes (7 tons) of uranium. All of these residues and wastes were deposited directly on the ground. Commercial Discount Corporation of Chicago purchased the residues in January 1967 and, after drying them, shipped much of the material to Cotter Corporation facilities in Canon City, Colorado. The material remaining at Latty Avenue was sold to Cotter in 1969, and Cotter dried and shipped some of the residues remaining at 9200 Latty Avenue to its mills in Canon City in 1970. Remaining residues included approximately 9,100 metric tonnes (10,000 tons) of Colorado raffinate (a term given to the residue by those who did the original processing at Mallinckrodt) and 7,900 metric tonnes (8,700 tons) of leached barium sulfate.

In 1973 Cotter shipped undried Colorado raffinate to Canon City and transported the leached barium sulfate plus 30 to 40 cm (12 to 18 in.) of topsoil for dilution purposes to West Lake Landfill in Bridgeton, Missouri. Cotter informed the NRC of this activity in early 1974.

In 1976 NRC measurements of radiation levels and radionuclide concentrations in soil indicated that residual uranium and thorium concentrations and exposure levels at HISS and Futura exceeded existing guidelines for use of the property without radiological restrictions. ORNL performed a radiological characterization of the properties in 1977, before their occupation by the present owner. Surface contamination exceeding DOE guidelines for thorium and radium was found in and around the buildings and in the soil to depths of 45 cm (18 in.) (ORNL 1977).

In June 1977 the building and grounds at 9200 Latty Avenue were purchased by Mr. E. Dean Jarboe, who currently operates Futura Coatings, Inc. Mr. Jarboe prepared the property for use by demolishing some buildings and erecting some new ones and clearing a 1.4-ha (3.5-acre) tract of land surrounding them. Material resulting from this cleanup [approximately 9,900 m^3 (13,000 yd^3)] was placed in interim storage on the eastern portion of the property (HISS) (ORAU 1981).

In 1984 DOE directed BNI to provide radiological support for remediation of a section of property along Latty Avenue under consideration for street improvements by the cities of Berkeley and Hazelwood. Approximately 10,700 m^3 (14,000 yd^3) of contaminated soil was added to the existing pile at HISS as a result of this cleanup effort and cleanup of an area at HISS used for office trailers and a decontamination pad. Based on results of surveys performed during support of road and drainage improvement projects long Latty Avenue, 3,517 m^3 (4,600 yd^3) of contaminated soil was removed and placed in a second storage pile at HISS in 1986. The total volume of contaminated soil in storage at HISS is approximately 24,500 m^3 (32,000 yd^3).

2.3 ENVIRONMENTAL SETTING

2.3.1 Climate

The St. Louis area has a modified continental climate. Major regional air masses influence a four-season climate that has few prolonged periods of extreme cold, heat, or humidity. Snowfall has averaged less than 50 cm (20 in.) each winter since 1930.

Temperatures reach 0°C (32°F) or lower for fewer than 20 to 25 days in most years. Summers are warm, with maximum temperatures of 32°C (90°F) or higher occurring an average of 35 to 40 days per year. Normal annual precipitation for the St. Louis area is about 92 cm (35 in.). Winds are predominantly from the south, with a mean speed of 15 km/h (9.5 mph).

2.3.2 Geology and Stratigraphy

This section presents a summary of the geology of the St. Louis area, followed by a discussion of salient site-specific geologic information. Detailed descriptions of regional and site-specific geology may be found in BNI 1983b, 1985c, 1989d, and 1990a and Weston 1982.

St. Louis Area

The St. Louis area is located within the Central Stable Region of the Canadian Shield. The Precambrian crystalline rocks of the Canadian Shield are overlain by approximately 1,830 m (6,000 ft) of Paleozoic sedimentary rocks consisting of sequences of sandstones, shales, and limestones and Quaternary-age, unconsolidated glacial tills, loess, and fluvium from the major rivers in the area. A generalized stratigraphic column for the St. Louis area is presented in Figure 2-6, and a generalized bedrock geologic map is presented in Figure 2-7.

The bedrock units in the St. Louis area are nearly flat-lying, with a regional dip of less than 1 degree to the northeast resulting from flexure from the Ozark Dome. Structural features in the area include folds, domes, and faults. Although St. Louis is located in the tectonically inactive Central Stable Region, it is near the tectonically active Mississippi Embayment, which includes the New Madrid Seismic Zone. Estimates of earthquake intensity, for a 10 percent expectation during a 50-year period, range from VII to VIII on the Modified Mercalli Intensity scale (BNI 1983b).

St. Louis Downtown Site

SLDS is located on the western edge of the Mississippi River, 11 km (7 mi) downstream of the confluence of the Mississippi and Missouri rivers, on the present-day floodplain of the Mississippi River. Figure 2-8 provides a generalized stratigraphic section and geologic description of the subsurface materials encountered during site investigations. A layer of rubble and fill (disturbed material) with an average thickness of 4 m (13 ft) is present over most of the property. Beneath the disturbed materials, unconsolidated deposits composed of stratified clays, silts, sands, and gravels are present. The unconsolidated deposits have been divided into upper and lower units. The upper unit is a clayey silt with interbedded silty clay, clay, silt, and sandy silt. The thickness of this unit ranges from 3 to 9 m (10 to 30 ft). Evaluation of soil boring data suggests that this unit is laterally continuous across the property. The lower unit is a silty sand that grades laterally to a sand toward the Mississippi River and is present only in the eastern portion of the property. The observed thickness of the unit ranges from 0 to 18.3 m (0 to 60 ft), increasing in thickness with increasing depth to bedrock and proximity to the Mississippi River. Beneath the unconsolidated deposits, a limestone bedrock unit is present. The depth to bedrock ranges from 5.9 m (19.5 ft) on the western side of the property to 24.4 m (80 ft) near the Mississippi River. The limestone is hard and microcrystalline and contains chert nodules. Examination of rock core samples indicates that the upper 1.5 m (5 ft) of the limestone is moderately fractured (200- to 600-mm spacing), with the discontinuities oriented normal to the core axis.

St. Louis Airport Site and Ball Field Area

Figure 2-9 presents a generalized stratigraphic column for SLAPS and the ball field area, based on information collected from site investigations. The site stratigraphy is divided into six units. The upper four units are composed of Holocene and Pleistocene unconsolidated materials including fill, loess, lacustrine, and glacial deposits. These unconsolidated materials range in thickness from 15.2 to 24.4 m (50 to 80 ft) across the properties. Beneath the unconsolidated deposits, bedrock units include Pennsylvanian, undifferentiated cyclothem deposits and Mississippian limestone. Pennsylvanian

undifferentiated rocks compose the upper bedrock unit in the eastern portion of the SLAPS/ball field property. Mississippian limestone composes the rest of the unit.

Soil samples were collected and analyzed to characterize the physical and geochemical properties of the undisturbed unconsolidated deposits. Table 2-2 summarizes the results of these tests. Discussions of test methodology are presented in BNI 1989b and Weston 1982. A listing of individual test results is presented in Appendix G. Results of the laboratory soil testing and visual observations of the samples indicate that the lacustrine deposits (Unit 3) are, based on their physical properties, divided into three subunits (3T, 3M, and 3B). Subunits 3T and 3B (top and bottom of Unit 3) have similar properties, but Subunit 3M (middle of Unit 3) exhibits different physical properties. This subunit is a high-plasticity clay whose permeability is one to two orders of magnitude lower than the remainder of Unit 3. Subunit 3M is thought to play a major role in groundwater flow and solute transport at the SLAPS/ball field properties. The areal distribution of this subunit was found to be discontinuous. Figure 2-10 is a map of the approximate areal distribution of Subunit 3M. [Note: The well identifiers on Figure 2-10 and other figures provide information about the locations of each well. For example, B16W02S (or D) may be broken down as follows: B - Bechtel-installed borehole or well; 16 - last two digits of work breakdown structure (WBS) (i.e., SLDS WBS number is 116); W - well; 02 - well number; S - shallow aquifer (or D - deep aquifer).]

Another finding from examination of Table 2-2 is that the uranium distribution ratios for unit 2 (loess) are 10 to 20 times higher than those for unit 3 (lacustrine deposits). Uranium was the only radionuclide used in distribution ratio measurements because, under normal geochemical conditions, uranium is the most mobile of the common radionuclides at the properties. Roy F. Weston, Inc. (RFW) examined the clay mineralogy of loess and the lacustrine deposits using X-ray diffraction data (Weston 1982). The investigation revealed that the clay mineralogy of the loess is dominated by smectite (and other complex, mixed-layer silicates), and the lacustrine deposits are dominated by illite or illite-chlorite assemblages. The complex, mixed-layer silicates have greater sorptive capacity than illite or

chlorite. The effective cation exchange capacities for the two units do not show a significant disparity, indicating that the dominant sorptive mechanism is adsorption rather than ion exchange.

Latty Avenue Properties

The stratigraphy of HISS and Futura is similar to that observed at the SLAPS/ball field properties. A single geologic borehole (HISS-9A) was drilled to a depth of 18.3 m (60 ft) to facilitate characterization of the site stratigraphy. The stratigraphy is divided into:

- 0 to 6.7 m (0 to 22 ft) of loess (analogous to Unit 2 at SLAPS),
- 6.7 to 14.6 m (22 to 48 ft) of lacustrine deposits (analogous to Subunit 3T), and
- 14.6 to 18.3 m (48 to 60 ft) of lacustrine deposits (analogous to Subunit 3M).

The presence of glacial deposits underlying the lacustrine deposits and the depth to bedrock at the Latty Avenue properties have not been determined. Because of the proximity of HISS and Futura to SLAPS and the ball field area, the soil properties at each are thought to be similar.

2.3.3 Hydrology, Hydrogeology, and Water Quality

This section summaries the regional and site-specific hydrology and hydrogeology. Detailed discussions of hydrology and hydrogeology are presented in BNI 1985c, 1989d, and 1990a and Weston 1982.

St. Louis Area

The major surface water bodies are the Mississippi, Missouri, and Meramec rivers, which supply most of the drinking and industrial water for the St. Louis area including St. Louis, Missouri; East St. Louis, Illinois; and Granite City, Illinois (Figure 1-1). Approximately 82 percent of the 1,200 million gallons of water used daily in the St. Louis area is pumped from the Mississippi River; the other 18 percent is pumped from the

Meramec and Missouri rivers near St. Charles (BNI 1990a). All but one of the water supply intakes for these cities are located upstream of SLDS; East St. Louis draws a small percentage of its water from an intake located on the eastern bank of the river, approximately 3.2 km (2 mi) downstream of SLDS. The Mississippi River intakes for the City of St. Louis are well upstream (approximately 7 mi) of SLDS. The Chain-of-Rocks water treatment plant is located at approximately mile 190 on the Mississippi River; SLDS is approximately at mile 182.5. The confluence of the Missouri and Mississippi rivers is approximately at mile 195 (river mile 0 on the Missouri River) (Department of the Army 1977). Upstream of its confluence with the Missouri River, Mississippi River water is generally of good quality except for being very hard. Downstream of the confluence, however, the water tends to have high turbidity resulting from sediment transport and an increase in mineralization. Water from the Missouri River is moderately mineralized, hard, and highly turbid; treatment is necessary for most uses. The Meramec River water is generally of good quality; it is hard and the turbidity is normally low (Miller et. al. 1974).

The principal aquifers in the St. Louis area are located in the alluvial deposits associated with the major rivers. Well yields of up to 190 L/s (3,000 gpm) have been reported for production wells pumping from these alluvial aquifers. Aquifers are also known to exist in the Silurian- through Pennsylvanian-age bedrock formations. In the St. Louis area, the bedrock aquifers typically yield less than 3 L/s (50 gpm), and water quality tends to deteriorate with depth as a result of increased salinity and increased concentrations of other dissolved minerals. The chemical quality of groundwater from the alluvial aquifers is generally good, but the water is very hard and contains high concentrations of iron and manganese (Miller et. al. 1974).

St. Louis Downtown Site

The dominant surface water feature at SLDS is the Mississippi River, which is located near the eastern edge of the property. As mentioned previously, the rivers are the major water supply source for the St. Louis area. All but one of the water supply intakes for the

area are located upstream of SLDS; East St. Louis draws a portion of its water from an intake located on the eastern bank of the river, approximately 3.2 km (2 mi) downstream of SLDS.

SLDS is underlain by a portion of the Mississippi River alluvial aquifer. The alluvial aquifer at SLDS is composed of the upper and lower units of the unconsolidated deposits. The silt and sandy silt layers within the upper unit represent water-bearing strata that are thought to be in hydraulic connection with the silty sand and sand of the lower unit. The alluvial aquifer is underlain by limestone bedrock. The upper portion of the bedrock is a water-bearing zone with groundwater occurring in secondary porosity features (fractures). Primary (matrix) porosity of the limestone is low, resulting in groundwater flow primarily through secondary porosity features. The boreholes penetrating the bedrock did not reveal any strata that could act as an aquitard to isolate the bedrock from the alluvial aquifer. Thus, the upper bedrock is thought to be hydraulically connected to the alluvial aquifer.

The relationship of the alluvial aquifer to the Mississippi River was investigated using groundwater level and river stage data. Figure 2-11 is a hydrograph showing groundwater elevations from four wells monitoring the lower unit and river stage elevations. The hydrograph suggests that there is a correlation between river stage fluctuations and groundwater level fluctuations. To quantify this correlation, regression analyses were performed. Correlation coefficients obtained from the regression analyses ranged from 0.93 to 0.99, indicating good correlation among the data (a correlation coefficient of 1 indicates perfect correlation). This suggests that the alluvial aquifer is in hydraulic connection with the Mississippi River.

Figure 2-12 is a potentiometric surface map created from groundwater level and river stage measurements taken on June 9, 1989. The figure shows that the general direction of groundwater flow is toward the Mississippi River. However, near the river, there is an anomalous depression in the potentiometric surface that is thought to represent a transient condition created by river stage fluctuations. When the river stage rises, a temporary reversal of groundwater flow occurs, created by recharge from the river.

The potentiometric surface map and available site data were used to develop a conceptualization of groundwater flow at the property. Recharge to the area groundwater system is thought to occur by offsite inflow through the upper unconsolidated unit and bedrock, from infiltration of precipitation, and through river bed infiltration at the Mississippi River. Infiltration of precipitation at SLDS appears to be a minor source of recharge because of the large percentage of surface area that contains impervious or diversionary features (i.e., asphalt roads, parking lots, and buildings). The area groundwater system discharges to the Mississippi River during low river stage, as underflow beneath the river, and, possibly, as recharge to the bedrock groundwater system.

Investigations conducted at the property include measurement of aquifer characteristics that are related to groundwater flow and solute transport in the groundwater system. A summary of these measurements is presented in Table 2-3. The measurement methodologies and results are discussed in BNI 1990a. Insufficient information is available to quantify the average linear groundwater velocity at the property; however, based on the materials present and the measured hydraulic gradients, the average linear groundwater velocity is estimated to be 3 to 6 m/yr (10 to 20 ft/yr) in the lower unit and 0.03 to 0.3 m/yr (0.1 to 1 ft/yr) in the upper unit. The uranium distribution ratio for the upper unit indicates that transport of uranium would be significantly retarded relative to groundwater movement. Based on soil properties from similar geologic settings and the uranium distribution ratio, the uranium migration rate is estimated to be 300 to 400 times slower than the groundwater velocity.

St. Louis Airport Site and Ball Field Area

The primary surface water feature at SLAPS and the ball field property is Coldwater Creek, which is approximately 30 km (19 mi) long and drains an area of about 118 km^2 (46 mi^2); at McDonnell Boulevard, the creek has a drainage area of approximately 32 km^2 (12.3 mi^2) (Hauth and Spencer 1971). RFW performed a base flow survey of Coldwater Creek at SLAPS and determined that the average base flow was 0.07 cms (2.5 cfs) (Weston 1982). The creek discharges into the Missouri River, north of its confluence with the Mississippi River (Figure 1-1). Coldwater Creek is not used for drinking water; however, two municipal water intakes are present on the Mississippi River, downstream of

the discharge of Coldwater Creek: the City of St. Louis Chain of Rocks Plant and the East St. Louis Plant. Water quality data for Coldwater Creek at high and low flow are presented in Table 2-4. The water samples were collected at crossing points of the creek with I-70 and I-270, which are upstream and downstream, respectively, of the properties. The pollutants of major concern are oil products transported into the stream by surface runoff from surrounding areas. Coldwater Creek empties into the Mississippi River at Missouri River mile 7 (Coldwater Creek mile 0) (Department of the Army 1977).

Hydrogeologic investigations indicate that two groundwater systems exist in the unconsolidated deposits at the properties. The upper groundwater system is contained in Unit 2 and Subunit 3T (loess and lacustrine deposits). The lower groundwater system is present in Subunit 3B and Unit 4 (lacustrine and glacial deposits). The two groundwater systems are separated by an aquitard composed of Subunit 3M (lacustrine deposits). However, in the eastern portion of the properties, the aquitard is absent, and the upper and lower groundwater systems become a single groundwater system. Comparison of groundwater level measurements from two monitoring wells screened in the Pennsylvanian undifferentiated bedrock with those from wells screened in the lower overburden suggests that the bedrock is hydraulically connected to the unconsolidated deposits.

Typical hydrographs for monitoring wells screened in the upper and lower portions of the unconsolidated deposits are shown in Figures 2-13 and 2-14. The hydrographs for monitoring wells screened in the upper system show the groundwater levels to be variable, with up to 2.7 m (9 ft) of variation over the course of a year. The hydrographs for monitoring wells screened in the lower groundwater system show less variability, approximately 1.5 m (5 ft) or less during a year. The higher variability in the upper system is thought to be a result of the greater influence of individual precipitation events and evapotranspiration effects on the upper groundwater system.

Figures 2-15 and 2-16 present potentiometric surface maps of the upper and lower groundwater systems for June 23, 1989. The upper groundwater system shows a north-northwestern flow direction, generally toward Coldwater Creek. The lower

groundwater system shows a northwest-western flow direction. Both potentiometric surfaces indicate that the southeastern corner of SLAPS is the upgradient end of the properties.

Comparison of groundwater level elevations for shallow and deep monitoring well pairs shown on the potentiometric surface maps (M10-25S and D, M10-15S and D, M10-8S and D, and M13.5-8.5S and D) indicates that a head differential between the upper and lower systems is present. In the eastern and central portions of SLAPS, the groundwater level elevations show a head differential of between 0.3 and 2.4 m (1.2 and 7.7 ft), which is indicative of a downward flow potential (from the upper to the lower groundwater system). In the western portion of SLAPS, head differentials of -0.6 to -1.2 m (-2 to -4 ft) occur, which is indicative of an upward flow potential (from the lower to the upper groundwater system). The change from downward flow potential to upward flow potential is probably a result of a lowering of the head in the upper groundwater system by seepage into the Coldwater Creek channel.

The available hydrogeologic data for the properties were used to develop a conceptualization of the groundwater flow. Recharge to the upper groundwater system is thought to occur from offsite inflow of groundwater, infiltration of precipitation, vertical seepage from the lower groundwater system where upward flow potentials exist, and, during high creek stage, from creek bed infiltration. Discharge from the upper groundwater system probably occurs by offsite outflow, seepage into Coldwater Creek during low creek stage, and vertical seepage into the lower groundwater system where downward flow potentials exist. Recharge to the lower groundwater system is thought to occur by offsite inflow, infiltration of precipitation (in the eastern portions of the properties, where the aquitard is absent), and vertical seepage from the upper groundwater system, where a downward flow potential exists. Discharge from the lower groundwater system probably occurs by offsite groundwater outflow and vertical seepage into the upper groundwater system where there is an upward flow potential.

Investigations conducted at the properties include measurement of hydrogeologic and hydrogeochemical parameters to determine the groundwater flow and solute transport characteristics of the site materials. These measurements are summarized in Table 2-5.

Measurement methodologies and individual test results are presented in BNI 1989b, Weston 1982, and Appendix G. The calculated average linear groundwater velocities, shown in the table, for the upper groundwater system range from 2 to 10 times faster that those calculated for the lower groundwater system. The slower groundwater velocity in the lower system probably reflects the heterogeneity of the glacial deposits (Unit 4), which vary from a clayey gravel to a silty clay. Calculation of vertical velocity through the aquitard (Subunit 3M) was not included in the table because of the number of variables associated with this unit (e.g. thickness, hydraulic gradient, flow direction, variations in depth of monitored intervals relative to the aquitard, and hydraulic conductivity variations). An estimate of the vertical velocity through the aquitard at well pair M10-15S and D can be made by using an aquitard thickness of 7.6 m (25 ft) and a head differential of 2.3 m (7.7 ft). The resulting average linear velocity (based on vertical hydraulic conductivities in Table 2-5) ranges from 0.003 to 0.2 m/yr (0.01 to 0.5 ft/yr). Thus, it would take a water molecule between 50 and 2,500 years to pass through the aquitard. The distribution ratios presented in Table 2-5 indicate that uranium migration is retarded relative to groundwater flow. The retardation factors for the upper groundwater system and aquitard can be estimated, assuming the distribution ratio approximates the distribution coefficient, from:

$$R = (1 + (p/n)\, K_d)$$

where:

R = retardation factor (dimensionless)

p = bulk density (g/cm^3)

n = porosity (dimensionless)

K_d = distribution coefficient $\approx$ distribution ratio (ml/g) (Gillham 1982)

The velocity of solute transport is related to the average linear groundwater velocity and the retardation factor by the expression:

$$V_s = V_g/R$$

where:

V_s = velocity of solute transport (length/time)

V_g = average linear groundwater velocity (length/time)

R = retardation factor (dimensionless)

The retardation factors for the upper groundwater system range from 72 to 1,234, and for the aquitard is 23. Thus, the uranium migration rates are between 72 and 1,234 times slower than the average linear groundwater velocity. The uranium migration rate through the aquitard is approximately 23 times slower than groundwater movement. Thus, for the previously described conditions at wells M10-15S and D, dissolved uranium would take between 1,150 and 57,500 years to migrate through the aquitard.

Latty Avenue Properties

The primary surface water feature in the HISS/Futura area is Coldwater Creek. The creek's hydrologic features are discussed in the SLAPS/ball field hydrology section. Surface water quality samples were collected from drainage ditches at HISS and Futura and from Coldwater Creek, 1.6 km (1 mi) downstream of the property to determine concentrations of radioactive constituents. Concentrations of lead-210, radium-226, and thorium-230 in the samples range from less than 1 to 7, less than 1 to 2, and less than 1 to 2 pCi/L, respectively [all values are below the maximum permissible concentrations specified in 10 Code of Federal Regulations (CFR) Part 20].

Hydrogeologic investigations at the property have focused on the uppermost groundwater system. Figure 2-17 presents typical hydrographs for groundwater levels in wells monitoring the uppermost groundwater system. The hydrographs indicate that groundwater levels typically do not vary by more than 1.5 m (5 ft) over the course of a year.

Figure 2-18 is a potentiometric surface map of HISS and Futura for March 22, 1989. The map shows that the groundwater flow direction is radial (i.e., flow is away from the property in all directions). The mechanism for the creation of this radial flow pattern is

under investigation, but the center of the radial pattern appears to be associated with an area of poor surface drainage on the eastern edge of the HISS stockpile area.

Groundwater flow patterns suggest that recharge to the upper groundwater system is occurring in the east-central area of the property. Discharge from the uppermost groundwater system occurs as offsite outflow of groundwater, with a portion of this groundwater probably discharging into Coldwater Creek during low creek stage. Discharge may also be occurring as vertical flow to a lower groundwater system, but insufficient information is available to characterize this potential flowpath.

Hydrogeologic parameters, measured to determine the groundwater flow characteristics of the uppermost groundwater system, are summarized in Table 2-6. Measurement methodologies and results are presented in BNI 1985c and 1990d. The average linear velocities fall within the same general range as those determined for the SLAPS/ball field properties for the upper groundwater system. Although no distribution ratio measurements have been taken on property soils, the proximity of HISS and Futura to the SLAPS/ball field properties and the similar appearance of the soils suggest that the distribution ratios are similar. Thus, uranium migration is significantly retarded relative to groundwater flow.

2.3.4 Ecological Resources

Typical trees and shrubs of floodplain forests in the area include silver maple, eastern cottonwood, willow, hackberry, elm, ash, and box elder (Bragg and Tatschl 1977). Box elder predominates in the lowland area near Coldwater Creek. Site vegetation consists of a mixture of prairie species, disturbance-related aggressive species, and remnants of landscape plantings (i.e., plants typical to old fields and less-maintained landscaped lawns). Typical species include various grasses, wild carrot, asters, clover, dandelion, goldenrod, dock, milkweed, ragweed, and thistle.

The vertebrate fauna of the area consists of species that have adapted to urban encroachment. Species of birds observed on the St. Louis site include grasshopper sparrow, house sparrow, rock dove, mourning dove, red-winged blackbird, grackle, starling, cardinal,

goldfinch, warbler, mallard, common crow, and robin. Mammals are represented by opossum, prairie mole, white-footed mouse, house mouse, Norway rat, short-tailed shrew, striped skunk, squirrel, and cottontail rabbit. Burrowing mammals (e.g., woodchuck and eastern mole) have ranges and habitats that encompass the site.

Other than the Mississippi River near SLDS, Coldwater Creek is the major aquatic habitat in the immediate area. Aquatic flora and fauna of Coldwater Creek downstream of the airport are restricted to species tolerant of the polluted water and turbid, silty conditions. These conditions are probably the result of contamination (e.g., from gasoline and oil) and high sediment yield in the runoff waters from the surrounding industrial facilities. Fish in Coldwater Creek downstream of the airport include carp, green sunfish, black bullhead, and seven species of minnows and suckers. The invertebrate community is dominated by aquatic worms (Tubificidae) and midge larvae (Chironomidae).

According to the U.S. Department of Interior, Fish and Wildlife Service, Columbia Field Office, the only federally threatened or endangered species that may occur in the vicinity of the site is the bald eagle. Although the bald eagle has been observed in St. Louis County, most observations have been of migrating and wintering individuals along the Missouri River. Furthermore, there is no critical habitat for the bald eagle near the site (Dept. of Interior 1989).

2.3.5 Historical Resources

Within one mile of SLDS are two landmarks listed on the National Register of Historic Places. Also, almost the entire area west and northwest of the property and west of I-70 is included in the official historic district of Hyde Park. In addition, there is one location in Hazelwood listed on the National Register of Historic Places (East-West Council 1980). Although DOE does not expect any adverse effect on any of these landmarks, the state Historical Preservation Office will be contacted for confirmation; DOE expects the office to issue a determination of no effect.

2.3.6 Land Use

The greater St. Louis metropolitan area is a diverse hub of transportation, commerce, and industry. Land use within a 1.6-km (1-mi) radius of SLDS represents a mixture of public, agricultural, industrial, commercial, and residential activities. The Mark Twain Freeway (I-70) is located along the western border of SLDS.

SLAPS is zoned for industrial use. The south-central and eastern portions of the property are in the approach zones of runways 17 and 24, respectively, at the adjacent Lambert-St. Louis International Airport. Consequently, the height of any developments on these portions of SLAPS will be limited to maximums imposed by the Federal Aviation Administration (St. Louis Airport 1980; R. W. Booker & Associates 1981; City of Hazelwood undated). At present, SLAPS is used only for temporary storage of drums containing drill spoils and other radioactive waste resulting from DOE characterization activities. The nearest population center is more that 2.4 km (1.5 mi) north of the property. More than two-thirds of the land within 0.8 km (0.5 mi) of the property is used for transportation-related purposes, primarily Lambert-St. Louis International Airport. Land immediately adjacent to the property is used for transportation, commercial, industrial, and recreational purposes, or is vacant.

The roads around SLAPS are heavily traveled during the work week and provide major access to employment centers in the area. The transient population within approximately 1.6 km (1 mi) of the property includes 37,000 full-time workers. Average daily traffic in 1982 was 43,000 vehicles on Lindbergh Boulevard and about 21,000 vehicles on McDonnell Boulevard in the area of Lindbergh Boulevard. The vehicle count was about 16,000 per day on McDonnell Boulevard near SLAPS, about 18,000 per day on McDonnell Boulevard north of Airport Road, and about 32,000 per day south of Airport Road. About 10,000 vehicles per day use Banshee Road between Lindbergh and McDonnell Boulevards (Missouri Department of Highways 1982).

The Latty Avenue Properties are zoned for industrial use, and the surrounding area is primarily industrial and commercial. Because of the industrial development in the area, Latty Avenue is used primarily by large trucks carrying supplies and equipment and by employees driving personal vehicles to and from industries adjacent to Latty Avenue (Argonne 1984).

Three spurs of the Norfolk and Western Railroad parallel the western boundary of HISS. The main spur is owned by Norfolk and Western; Wagner Electric Corporation, a landowner on the northern side of Latty Avenue, owns the others. The easternmost spur is unused, but the other two are used for deliveries in the industrial area around HISS (Argonne 1984; Crotwell 1983). The HISS property currently houses two temporary waste storage piles, a 12- by 56-ft trailer used as office space for the property caretaker, and a 24- by 56-ft trailer used as a public information office.

The residential areas nearest HISS are about 0.5 km (0.3 mi) to the east in the City of Berkeley. Located about 1.2 to 1.6 km (0.75 to 1.0 mi) east and southeast of the property in Hazelwood and Berkeley are several high-density residential areas that include single-family houses and apartment buildings (R. W. Booker & Associates 1981; City of Hazelwood undated; Peat et al. 1980).

2.3.7 Surface Features

Following closeout of the MED/AEC operations at SLDS, buildings owned by the government were demolished, or ownership was transferred to Mallinckrodt as part of the contract settlement. Several plants within the Mallinckrodt facility containing about 60 buildings were involved in the operations; fewer than 20 remain. Several new buildings constructed at the facility have been used for commercial chemical production since 1962. The surface of SLDS has been drastically altered by man. The original area slope to the Mississippi River is evident, but all other irregularities that may have existed have been modified.

The surface of SLAPS varies from 4.5 to 6.0 m (15 to 20 ft) above Coldwater Creek and slopes from east to west. The property surface is generally flat; however, because the fill placed over the property in the early 1970s was not spread evenly, compacted, or revegetated, differential settling and erosion have occurred, resulting in an irregular surface.

The ground surface at Futura Coatings and HISS ranges from about 157 m (513 ft) above mean sea level (MSL) near Latty Avenue to about 161 m (525 ft) above MSL near the pile. The largest of the two existing contaminated piles is approximately 8 m (26 ft) high (Surdex 1984). The surface slopes gently from the waste pile at HISS to the west and south toward Coldwater Creek.

2.3.8 Surface Water

The natural drainage of SLDS has been eliminated by urban development, and storm runoff is now controlled by a system of sewers equipped with weirs to direct excess flow to the river. Levees completed in the 1960s have prevented frequent flooding of the property by the Mississippi River. Protection against flooding is provided up to a river stage of 16 m (52 ft) with 0.6 m (2 ft) of freeboard. The 500-year flood stage is estimated to be 14 m (47 ft) or 134 m (440 ft) above MSL.

The only surface water near SLAPS and the vicinity properties is Coldwater Creek, which borders the western side of SLAPS. Coldwater Creek originates about 5.8 km (3.6 mi) south of the property, flows for a distance of 153 m (500 ft) along the western side of SLAPS, and discharges into the Missouri River about 24 km (15 mi) northeast of the property. The average flow measured near the airport in September 1978 was about 0.09 m^3/s (3 ft^3/s) (DOE 1980).

The Latty Avenue Properties are within the Coldwater Creek drainage basin, about 0.8 km (0.5 mi) downstream of SLAPS. The creek originates approximately 7.4 km (4.6 mi) south of the properties. HISS is about 61 m (200 ft) east of the creek. Based on drainage areas, the 7-day, 10-year low flow of Coldwater Creek at HISS is estimated to be about

0.04 m^3/s (1.5 ft^3/s). Stormwater runoff flows offsite to the north into a stormwater drain along Latty Avenue that drains into Coldwater Creek (Argonne 1984).

The 100-year flood level at HISS is about 159 m (520 ft) above MSL. Therefore, in the event of a flood of 100-year or greater magnitude, the majority of the property, including the base of the contaminated waste piles, would be inundated. The two existing piles, and any future construction on the property, is protected to a level 0.7 m (2 ft) above the 100-year flood level (Argonne 1984; FEMA 1977).

2.4 NATURE AND EXTENT OF CONTAMINATION

This section discusses the origins and nature of radioactive, nonradioactive, and chemical contamination at the St. Louis site. The discussion is based on information compiled from reports of previous surveys and historical information about operations conducted at SLDS and various material transfers to the other FUSRAP locations in St. Louis.

Extensive sampling and analysis have been carried out to characterize the nature and extent of contamination at the St. Louis site. To the extent practicable, the work was based on site history and previous radiological surveys. The major objectives of the sampling were to (1) determine the vertical and horizontal bounds of radioactive contamination and any chemical contamination associated with it, (2) identify and quantify the contaminants present, and (3) assess the potential health hazards from the contamination to workers performing remedial action.

2.4.1 Origins of Contamination

Contamination being addressed by FUSRAP at the St. Louis site originated from uranium and thorium processing operations carried out at the former Mallinckrodt Chemical Works site, now known as SLDS, between 1942 and 1957 (see Subsection 2.2). Processes conducted at that time included (1) manufacturing of uranium dioxide (UO_2) and uranium trioxide (UO_3) in production quantities from pitchblende; (2) production of uranium

tetrafluoride [green salt (UF_4)]; (3) production of uranium derby metal (subsequently vacuum-recast to form purified ingot metal); (4) machining of uranium metal rods for reactor fuel slugs; (5) conversion of UF_4 to UO_2 or uranium oxide (U_3O_8) (black oxide); (6) recovery of scrap uranium metal; (7) production of uranyl fluoride (UO_2F_2); (8) extraction and concentration of thorium-230 from pitchblende raffinate; and (9) experimental processing of very-low-enrichment UF_4. During the period of operation under MED/AEC, the company processed more than 45,000 metric tonnes (50,000 tons) of natural uranium products at the facility in St. Louis. Figure 2-19 is a flowchart of uranium processing operations conducted at SLDS.

Pitchblende used as one of the feedstocks at SLDS contained approximately 0.3 Ci of radium per ton of uranium. This feedstock was separated into radium-226 and its daughters, along with sulfate and other unwanted impurities. This residue fraction, called K-65, was not processed or concentrated further but was transported to DOE facilities in Ohio and New York, where it is currently in storage. Process materials sent to SLAPS included pitchblende raffinate residues, radium-bearing residues, barium sulfate cake, Colorado raffinate residues, and contaminated scrap. (Raffinate is the residue remaining after extraction of a liquid with a solvent.) Most of the residues were stored in bulk on open ground. In the mid 1960s, most of the residues were sold and removed from SLAPS. The structures were demolished, buried onsite, and covered with 0.3 to 1 m (0 to 3 ft) of clean fill material. It is believed that the rubble was buried primarily in the western portion of the property. Figure 2-5 shows former areas of land use and waste storage at SLAPS. Subsequently, residues were transferred from SLAPS to the Latty Avenue Properties in 1966 (Subsection 2.2.3).

Since MED/AEC activities ceased at SLDS in 1957, portions of the current facility, Plant 6, have been used to store columbium-tantalum ore, which contains uranium and thorium and is an NRC-licensed material. Mallinckrodt, Inc., prepares tantalum and columbium products for use in several industries and currently maintains an NRC license to recover the tantalum and columbium from ores and slags through chemical operations. The chemical processing is performed in Plant 5 buildings. Potassium compounds, including naturally occurring potassium-40, are stored in warehouses at Plants 6, 7N, and 7W. Even

though columbium-tantalum ore and potassium-40 have been handled at SLDS, both are low-level radioactive materials and neither was associated with MED/AEC activities; they are not, therefore, subject to FUSRAP activities.

Uranium-238, radium-226, thorium-230, and thorium-232 were selected as indicator parameters for the radiological portion of the RI. These four radionuclides were selected based on the half-lives of the radionuclides in the associated decay chains, historical information on the radionuclides in the ore, and a source term analysis that was conducted for each property. For the source term analysis, selected samples were analyzed for uranium-238, uranium-235, uranium-234, thorium-227, thorium-232, thorium-230, actinium-227, radium-228, radium-226, radium-224, lead-210, and polonium-210. The results of the source term analyses are presented in Appendix D.

Background and Current Cleanup Guidelines

Radionuclides associated with uranium processing also occur naturally in soil at low levels. To determine the naturally occurring levels of these radionuclides in soil in the St. Louis area, background data were collected before the start of the characterization activities (Table 2-7). [Background concentrations of radionuclides found in groundwater and surface water and of radon in air at distances of 8 to 32 km (5 to 20 mi) from SLAPS and 8 to 24 km (5 to 15 mi) from HISS are included in Subsection 2.4.2.] Figure 2-20 shows the locations from which background samples and measurements were taken. Location 1 is open, grassy land with no trees and with no structures within about 0.2 km (0.1 mi). It is owned by the City of St. Louis and is expected to become part of the airport during planned expansion. Location 2 is also open, grassy land with no trees; there are no structures within 0.5 km (0.3 mi). Location 3 is an open, grassy area with trees; it is near a school surrounded by a park and near a gasoline station.

Current DOE guidelines governing remedial action for radiological constituents in soil and on building surfaces at the St. Louis site are presented in Table 2-8. Appendix B provides DOE Order 5400.5, residual radioactive material guidelines. Guidelines for uranium in soil are calculated by DOE on a site-specific basis; for the St. Louis site,

50 pCi/g of residual uranium-238 in soil is assumed, based on the residual radioactive (RESRAD) material code computer model. This assumption is very conservative, and the final cleanup criteria will be part of the ARAR determination for the site. DOE policy requires that all exposures to radiation be limited to levels that are as low as reasonably achievable (ALARA). For sites to be released for unrestricted use, the intent is to reduce residual radioactive material to levels that are as far below authorized limits as reasonable considering technical, economic, and social factors. At sites where the residual material is not reduced to levels that permit release for unrestricted use, ALARA policy is implemented by establishing controls to reduce exposure to levels that are ALARA.

Analytical results for metals from SLAPS, SLDS, and the Latty Avenue Properties were compared with concentration ranges for metals in soil at various locations in the United States and other parts of the world. Mobile ion concentrations at SLAPS and the Latty Avenue Properties were compared with background concentrations. Table 2-9 shows the ranges of metal concentrations found in typical natural soils.

2.4.2 Radiological Conditions

Radiological conditions at SLDS and vicinity properties, SLAPS and vicinity properties, and the Latty Avenue Properties are discussed in the following subsections.

St. Louis Downtown Site

In 1977 ORNL conducted a radiological survey of portions of SLDS at the request of DOE. Results from this survey of the buildings show alpha and beta-gamma surface radioactivity levels and radionuclide concentrations in soil exceeding DOE limits for release of the property for use without radiological restrictions. For alpha surface contamination, the strictest limits applied to a group of radionuclides including radium-226 and thorium-230. The average and maximum limits for direct measurements are 100 and 300 dpm/100 cm^2, respectively; the removable alpha contamination guideline is 20 dpm/100 cm^2. These guidelines applied in areas where uranium ore was handled. In areas where uranium that contained no radium-226 was handled, less stringent guidelines of 5,000 and

15,000 dpm/100 cm^2 for average and maximum direct alpha measurements were applied. The removable alpha contamination guideline for those areas is 1,000 dpm/100 cm^2. Elevated external gamma radiation levels were measured at some outdoor locations and in some buildings. Radon and radon daughter concentrations in three buildings exceed guidelines for nonoccupational radiation exposure (ORNL 1981). Radon measurements in Building K1E average 6.4 pCi/L and are as high as 22 pCi/L. The highest radon concentrations in Buildings 52A and 101 are as high as 37 pCi/L and 69 pCi/L, respectively. The maximum radon daughter concentration of 0.07 WL was measured in Building 52A. Concentrations of uranium-238 up to 20,000 pCi/g and of radium-226 up to 2,700 pCi/g were found in subsurface soil during the exterior phase of this survey.

A 1988 radiological characterization conducted by BNI included performing walkover gamma radiation scans, measuring external gamma radiation levels, and collecting and analyzing surface and subsurface soil and groundwater samples. Results of the survey show that uranium-238, radium-226, thorium-232, and thorium-230 concentrations range from 1.3 to 95,000, 0.4 to 5,400, 0.4 to 700, and 0.3 to 98,000 pCi/g, respectively. The characterization results indicate surface contamination over many of the portions of SLDS surveyed. Soil sample analysis shows uranium-238, radium-226, thorium-232, and thorium-230 to be contaminants of concern (BNI 1990a).

Building surveys. Preliminary building surveys were conducted at SLDS in 1988 in 20 buildings (25, K1E, 50, 51, 51A, 52, 52A, 100, 101, 116, 116B, 117, 700, 704, 705, 706, 707, 708, 81, and 82) to determine whether radioactivity exceeding DOE guidelines was present. These buildings were included in the field investigation because of their use during and/or their proximity to MED/AEC operations. In addition, the roofs of 17 buildings (X, 501, R, P, Q, C, B, L, Z, 53, 56, F, G, 10, T, V, and W) were surveyed to determine whether emissions from buildings used for MED/AEC operations had contaminated adjacent building roofs. Because SLDS is an operating facility and interruptions of ongoing operations are necessary to perform comprehensive building surveys, only a limited characterization was conducted. In addition, the ongoing plant activities may render characterization findings invalid. Therefore, more detailed building surveys will be conducted immediately before remedial action. Surveys of the interiors of the plants,

including the establishment of radon monitors on the ground floor or basement level of selected buildings, and building roofs were also conducted. The average density of sampling in the SLDS building survey was one reading at every grid intersection at 1-m (3-ft) intervals for floors and one reading at every grid intersection at 5-m (15-ft) intervals for ceilings, walls, and roofs. Some buildings exhibit beta-gamma measurements exceeding DOE guidelines, but little removable contamination was found and average gamma exposure rates do not exceed DOE guidelines. Roof contamination was found on four buildings. Additional roof surveys revealed that some of the adjacent buildings have residual radioactive contamination. In all cases, the roof surfaces exhibit direct alpha measurements that are below guidelines (BNI 1990a). Radiological information for specific buildings are summarized below. Background concentrations were not subtracted from data collected in the BNI surveys.

A natural uranium criterion of 5,000 dpm/100 cm^2 was used as the surface contamination guideline based on analytical results for building deposit samples. Because uranium-238 is the primary contaminant at SLDS, this is the guideline that will be used for initial determination of whether DOE guidelines for radionuclide contamination have been exceeded. In areas where radium-226 or thorium is the major contaminant, the DOE radionuclide guideline applicable to that situation will be applied for final remedial action. The purpose of this survey was to determine whether radioactivity exceeding DOE guidelines existed, not to determine the absolute boundaries of contamination. Cleanup will be conducted to yield ALARA levels.

Summary results of the 1977 ORNL and 1988 BNI surveys are included in the following text. In most cases, the results were consistent. Buildings are shown in Figure 2-1.

- Building 25 Most of the beta-gamma contamination was found on walls and floors, and most was found to be nonremovable. The average external gamma radiation exposure rate is below DOE guidelines for habitable structures. Data from the 1988 survey of Building 25 are presented in Table 2-10 (BNI 1990a). The 1977 ORNL survey found that most measurements of alpha and beta-gamma

contamination on surfaces are at background levels; some exceeding background were found on laboratory benches (ORNL 1981). Beta-gamma dose rates range from 0.5 to 20 mrad/h. All removable alpha or beta contamination is at or near background levels. An external gamma radiation exposure rate of 18 μR/h was measured on the second story. Radon grab samples yield an average radon-222 concentration of 0.6 pCi/L and a maximum concentration of 1.3 pCi/L (ORNL 1981).

- Building K1E Beta-gamma contamination was found to be widespread and in excess of DOE guidelines for natural uranium on some of the walls and roofs. No removable contamination was found. Survey results for Building K1E are shown in Table 2-11 (BNI 1990a). The 1977 ORNL survey showed that beta-gamma residual surface radioactivity exceeds DOE guidelines for radium in several places. The average alpha contamination for the entire area is 500 dpm/100 cm^2. Measurements of direct and removable alpha and beta-gamma show no contamination. Radon measurements yield average concentrations ranging from 0.5 to 15.2 pCi/L and maximum concentrations ranging from 0.9 to 22 pCi/L (ORNL 1981).

- 50 Series Buildings This series consists of Buildings 50, 51, 51A, 52, and 52A. For all buildings (with the exception of 52A, in which the floors were inaccessible), most residual surface contamination was found on floors and walls. No removable contamination was detected. Survey results for these buildings are shown in Tables 2-12 through 2-16 (BNI 1990a). The 1977 ORNL survey showed Building 50 to have spots of elevated beta-gamma dose rates and/or alpha contamination exceeding uranium guidelines. No significant removable contamination was found on floors or walls. The Building 51 survey showed beta-gamma contamination on walls. External gamma radiation levels exceed background in several places. The Building 51A survey revealed low-level contamination to be widespread. Survey results for Building 52A showed little contamination on floors, but beta-gamma dose rates exceeding 1.0 mrad/h were found on the lower walls. The common roof area between Buildings 51A and 52A

has background beta-gamma and alpha readings in most areas. In Building 52, beta-gamma dose rates exceed DOE guidelines in several spots, principally on lower walls. Radon measurements yield average concentrations on the 50 series buildings of 0.4 to 15 pCi/L and maximum concentrations from 0.5 to 37 pCi/L (ORNL 1981).

- Building 100 Residual radioactivity exceeding guidelines is present on all surfaces. No measurements for removable contamination were found to exceed DOE guidelines. Survey results are summarized in Table 2-17 (BNI 1990a). The 1977 ORNL survey showed that observed beta-gamma dose rates are below DOE guidelines for radium. Alpha contamination was found to exceed guidelines. Overhead surfaces show no contamination (ORNL 1981).

- Building 101 Beta-gamma measurements were taken only on floors because the building was constructed after MED/AEC operations at SLDS were completed. No readings exceed DOE guidelines. Beta-gamma measurements on the floors range from 258 to 2,193 dpm/100 cm^2, with 930 dpm/100 cm^2 as the average. Exposure rates range from 6 to 48 μR/h, with 24 μR/h as the average (BNI 1990a). Four radon monitoring stations were established; levels range from 0.5 to 4.8 pCi/L. Survey results are summarized in Table 2-18. The ORNL survey showed the average external gamma radiation level to be 15 μR/h. Average radon concentrations range from 1.3 to 12 pCi/L, and maximum concentrations range from 3.6 to 69 pCi/L (ORNL 1981).

- 116 Series Buildings The 116 series consists of Buildings 116, 116B, and 117. Most beta-gamma measurements in these buildings exceed DOE guidelines. No removable contamination was found. Results for these individual building surveys are summarized in Tables 2-19 through 2-21 (BNI 1990a). The 1977 ORNL survey showed low-level alpha contamination over much of the floor and lower wall surfaces. Nonremovable alpha measurements do not exceed DOE guidelines for natural uranium. In the large section of the building and on the second level, beta-gamma measurements exceed DOE uranium guidelines at some points. Inside

Building 116B, all measurements are at the background level, but beta-gamma residual surface radioactivity exceeds guidelines in two areas on the roof. Building 117 contains beta-gamma radioactivity exceeding the DOE radium guidelines. Alpha contamination guidelines are exceeded over much of the floor and wall surfaces, but if uranium guidelines are applied, the values are well below contamination levels. Average radon concentrations range from 0.5 to 0.7 pCi/L, and maximum concentrations range from 0.7 to 1.1 pCi/L (ORNL 1981).

- Building 700 Most surfaces in Building 700 exceed DOE guidelines for residual surface; the contamination is nonremovable. Table 2-22 summarizes the survey results (BNI 1990a). The 1977 ORNL survey showed that beta-gamma residual surface radioactivity exceeds DOE guidelines for uranium at some spots on the floor and walls. The average radon concentration is 0.6 pCi/L, and the maximum concentration found is 0.9 pCi/L (ORNL 1981).

- 704 Series Buildings This series consists of Buildings 704, 705, 706, and 707. Most of the interior surfaces in these buildings have residual beta-gamma radioactivity exceeding DOE guidelines, and contamination on the roofs of these structures exceeds guidelines for both alpha and beta-gamma radioactivity. Beta-gamma contamination on floors exceeds DOE guidelines in all four buildings. No removable contamination was found in any of the buildings. Survey results for these buildings are summarized in Tables 2-23 through 2-26 (BNI 1990a). The ORNL survey showed that only beta-gamma dose rates at spots on floors and walls exceed the DOE guidelines for uranium in Building 704. The survey of Building 705 showed that measured nonremovable alpha and/or beta-gamma radiation levels exceed DOE guidelines for uranium at numerous points on the floors, walls, and ceilings. Building 706 has one area where beta-gamma dose rates exceed DOE guidelines, as does Building 707. Average radon concentrations range from 0.5 to 1.0 pCi/L, and maximum concentrations range from 0.7 to 1.2 pCi/L (ORNL 1981).

- Building 708 Most surfaces in Building 708 contain levels of radioactivity below DOE guidelines. The primary area showing beta-gamma contamination is the roof. No removable contamination exceeding guidelines was detected. A summary of the results is provided in Table 2-27 (BNI 1990a). The 1977 ORNL survey showed that none of the measurements taken in this building exceed the DOE guidelines for natural uranium. Beta-gamma dose rates average 0.09 mrad/h on the gravel surface roof. Average radon concentrations range from 0.6 to 1.0 pCi/L, and maximum concentrations range from 1.0 to 1.2 pCi/L (ORNL 1981).

- Building 81 No surface in Building 81 yields results exceeding guidelines, and no removable radioactivity exceeding DOE guidelines was found. Results are summarized in Table 2-28.

- Building 82 No residual radioactivity exceeding DOE guidelines exists on the roof or on the interior surfaces. No removable contamination exceeding DOE guidelines was detected. Table 2-29 provides a summary of the results.

Roof surveys also were conducted in Plant 1. The roof surfaces of Buildings Q, T, V, and W within Plant 1 show no measurements exceeding DOE guidelines. Other roofs surveyed in Plant 1 have some areas that slightly exceed DOE guidelines. In general, the contamination is low level and was found in isolated areas. Three roofs in Plant 2 were surveyed; Buildings 53, 56, and 501 within Plant 2 have some beta-gamma radioactivity exceeding uranium guidelines. Results of these additional roof surveys are provided in Table 2-30.

Soil survey. BNI conducted a soil investigation at SLDS and the adjacent city property. Results of the survey indicate the presence of subsurface contamination from the surface to a maximum depth of 12.8 m (42 ft). A total of 218 boreholes were drilled and sampled to determine the presence of radioactive contamination; 110 of these were also sampled for chemical constituents, and 9 were converted to monitoring wells. Borehole locations and areas of contamination are shown in Figure 2-21; boreholes were drilled in both exterior and interior locations. Table 2-31 shows the averages and ranges of radionuclide

concentrations found in soil around each plant and at the city property adjacent to Plant 7E (BNI 1990a). The total estimated volume of contaminated soil at SLDS and adjacent contaminated properties is 220,200 m^3 (288,000 yd^3). The following paragraphs summarize the locations and extent of radioactive subsurface soil contamination at each plant. Subsection 2.4.3 provides a summary of the chemical conditions at the property.

For purposes of discussion, a uranium-238 guideline of 50 pCi/g is assumed. The actual guideline will be established during the development of ARARs for the St. Louis site. A value of 50 pCi/g is believed to be conservatively low based on dose analyses, the application of ALARA, and the current use of the property. (Note: The borehole identifiers used in the following figures explain the types of samples collected from the boreholes. For example, R denotes a borehole sampled for radiological analysis only, whereas C denotes a borehole sampled for both radiological and chemical analyses.)

- Plant 1 Twenty-three boreholes were drilled, and soil samples were collected and analyzed; analytical results for seven of these boreholes exceed DOE cleanup guidelines for soil. Most elevated radioactivity in soil was found near Building K1E, and radium-226 is the primary soil contaminant (see Figure 2-22). Contamination at Plant 1 extends to a depth greater than 3 m (10 ft).

- Plant 2 Twenty-seven boreholes were drilled, and soil samples were collected and analyzed; samples from 13 exceed DOE cleanup guidelines. Most of the radioactivity exceeding guidelines was found near or beneath Buildings 51, 51A, 52, and 52A. Uranium-238 and thorium-230 are the primary soil contaminants (see Figure 2-23). Contamination at Plant 2 extends to a depth greater than 7 m (23 ft).

- Plant 5 Of the eight boreholes drilled, seven showed radioactivity exceeding guidelines; thorium-230 is the primary contaminant (see Figure 2-24). The maximum depth of contamination at Plant 5 is 3 m (10 ft).

- Plants 6 and 6E Sixty-four boreholes were drilled at Plants 6 and 6E, and 53 of the soil samples collected and analyzed exceed cleanup guidelines. In general, soil at Plant 6 exceeds guidelines across the entire area, and Plant 6E shows little residual radioactivity. Uranium-238 is the primary contaminant, and concentrations of radium-226 and thorium-230 exceed guidelines in some spots (see Figure 2-25). The maximum depth of contamination at Plant 6 is 6 m (20 ft).

- Plant 7 Of the 45 boreholes drilled at Plant 7, analytical results for soil from 32 showed uranium-238, radium-226, thorium-232, and thorium-230 in concentrations exceeding cleanup guidelines (see Figure 2-26). Radioactivity is distributed across the entire plant area; contamination extends to a depth greater than 6 m (20 ft).

- Plant 10 Thirteen boreholes were drilled at Plant 10; analytical results for soil from nine showed radioactivity exceeding cleanup guidelines. The contamination is distributed across the entire plant area, and uranium-238 and thorium-230 are the primary contaminants (see Figure 2-27). The maximum depth of contamination at Plant 10 is 2.1 m (7 ft).

- City property Twenty-one boreholes were drilled in this area, located west of the Mississippi River and east of the Chicago, Burlington, and Quincy Railroad; analytical results for soil from 16 showed radioactivity exceeding DOE cleanup guidelines. Uranium-238, radium-226, and thorium-230 seem to be spread across the entire area (see Figure 2-28). The maximum depth of contamination at the city property is 12.8 m (42 ft).

- Plant 7E Of the five boreholes drilled at Plant 7E, analytical results for soil from two showed radioactivity near the surface in excess of guidelines. The boreholes were drilled around the perimeter of the property because the entire area is covered with a stockpile of coal. Radium-226 and thorium-230 are the primary contaminants (see Figure 2-28). The maximum depth of contamination at Plant 7E is 0.3 m (1 ft).

Figure 2-29 shows areas of radioactive contamination at SLDS.

Drains and sumps. Eighty-four manholes at SLDS (Figure 2-30) were surveyed to determine whether residual radioactivity exists in the drainage pathways; sludge or sidewall samples were collected and analyzed from 50 of the manholes. One sample was collected from each manhole where available. Analytical results are given in Table 2-32. Thirty-five of the manholes showed residual radioactivity exceeding DOE uranium guidelines for surface soil contamination. When final building surveys are performed shortly before remedial action begins, the extent of contamination in each drainage pathway will be determined. This approach was selected because of ongoing operations at the property (BNI 1990a), which may render data collected several years before remedial action useless for the purpose of cleanup.

Groundwater investigations. Nine groundwater monitoring wells were installed to evaluate groundwater quality and to help determine groundwater flow directions (Figure 2-31). Well 9 was installed after the others and was only used to evaluate groundwater flow direction. Groundwater was sampled quarterly from July 1988 to April 1989; characterization data indicate that concentrations of uranium-238, radium-226, and thorium-230 range from less than 3×10^{-9} (which is the lowest level of detection) to 1.93×10^{-7}, 3×10^{-10} to 3.2×10^{-9}, and less than 1×10^{-10} to 3.7×10^{-9} μCi/ml, respectively. Table 2-33 shows minimum, maximum, and average values of radionuclides in groundwater at SLDS. Well B16W02S exhibits a maximum total uranium concentration of 193×10^{-9} μCi/ml. Well B16W01S contains maximum concentrations of radium-226 and thorium-230 of 3.2×10^{-9} and 3.7×10^{-9} μCi/ml, respectively. EPA has proposed an amendment to the Uranium Mill Tailings Radiation Control Act (40 CFR 192) to add 30×10^{-9} μCi/ml (30 pCi/L) as a guideline for concentrations of uranium in groundwater, which could result in a potential ARAR for the St. Louis site.

SLDS Vicinity Properties

The SLDS vicinity properties include the Norfolk and Western Railroad property; the Chicago, Burlington, and Quincy Railroad property; the Thomas and Proetz Lumber Company property; the PVO Foods, Inc., property; the McKinley Iron Company property;

and the St. Louis Terminal Railroad Association property. Survey activities at these properties included walkover gamma radiation scans, soil sampling, and gamma radiation logging. Residual radioactivity was found in soil at concentrations exceeding guidelines on five of the six properties. Analytical results for soil collected and analyzed from the six vicinity properties reveal elevated (exceeding DOE remedial action guidelines) concentrations of uranium-238, radium-226, thorium-232, and thorium-230 in surface soil on all the properties, with the exception of PVO Foods. One subsurface soil sample collected from the Thomas and Proetz property exceeds the DOE guideline concentration for radium-226. For all six vicinity properties surveyed, concentrations of uranium-238 range from less than 2 to 1,100 pCi/g. Radium-226 concentrations range from 0.5 to 300 pCi/g. Concentrations of thorium-232 and thorium-230 range from 0.8 to 160 and 0.9 to 2,100 pCi/g, respectively.

St. Louis Airport Site

Soil survey. ORNL performed radiological investigations at SLAPS and the surrounding area from 1976 through 1978. These investigations revealed elevated concentrations of uranium-238 and radium-226 in soil along and in the drainage ditches to the north and south of McDonnell Boulevard, probably from surface runoff from SLAPS (ORNL 1979).

In 1986 BNI conducted a radiological characterization of SLAPS to identify the radionuclides on the property at concentrations exceeding DOE guidelines and to determine the depths and areal limits of radioactive contamination. The subsurface investigation was conducted by drilling boreholes at most 33-m (100-ft) grid intersections; 102 boreholes were drilled. Wherever possible, continuous sampling was performed from the surface to undisturbed (natural) soil as identified by the field geologists. Surface soil samples were collected at 21 biased locations to help quantify conditions at the property perimeter and in the drainage ditches. These biased surface samples were analyzed for gamma-emitting radionuclides only.

This 1986 characterization indicated radioactive contamination at SLAPS extending to depths as great as 5.5 m (18 ft), with most contamination between 1.2 and 2.4 m (4 and 8 ft) (Figure 2-32). The volume of contaminated soil at SLAPS is 191,000 m^3 (250,000 yd^3). Soil sample analyses identified elevated levels of radium-226, uranium-238, thorium-232, and thorium-230 (BNI 1987a). These results are provided in Table 2-34.

External gamma radiation levels were measured as part of the quarterly sampling conducted for the environmental monitoring program. Levels at the property boundary have not changed notably since monitoring began in 1984. Annual averages are shown in Table 2-35.

Surface water and sediment survey. Additional information about radiological conditions at SLAPS has been obtained through the DOE environmental monitoring program conducted by BNI since 1984. The monitoring program has included quarterly collection of Coldwater Creek sediment samples upstream and downstream of SLAPS (Figure 2-33). Results of sediment analyses from 1984 through 1989 are presented in Table 2-36; the measured values have been fairly consistent since 1984. These values are within the range of typical soil concentrations, which for uranium-238 is about 1 pCi/g.

The monitoring program has also included quarterly collection of surface water samples from four locations, including the nearest drinking water intake downstream of the property, the Chain of Rocks Water Treatment Plant on the Mississippi River (see Figure 2-33). Sampling points were established both upstream and downstream of the property to evaluate background conditions and to determine the effect of runoff from the property on surface water. Results are presented in Table 2-37; concentrations of total uranium have remained stable since 1984.

Groundwater investigations. A well canvass was conducted in March 1989 to identify and investigate wells within a 4.8-km (3-mi) radius of SLAPS and HISS. The appropriate state and local agencies were contacted first, followed by door-to-door interviews within the designated area. Interviews were supplemented by review of permit records (permitting of water wells has been required since January 1987). The canvass identified eight wells within

the area, none of which is used as a source of drinking water. Four of the wells have been used for irrigation, one is capped and no longer used, and the other three are low-yield wells. One industrial well, drilled in 1988, supplies water for cleaning septic tanks. One domestic well was capped in 1962, and another has not been used since 1968. A hand-dug well dating back to the 1820s has not been used for the last 10 years. Figure 2-34 shows the locations of the wells identified in the 1989 canvass.

Groundwater samples have also been collected quarterly from 16 onsite monitoring wells (Figure 2-33); Table 2-38 presents the results of groundwater analyses from 1984 to 1989. The locations of the background monitoring wells are shown in Figure 2-35. The wells are located adjacent to old ball fields along Byassee Drive. The surrounding area is industrialized with no residential properties within the immediate vicinity. In several shallow wells, the measured values of uranium concentrations are considerably higher than those occurring naturally in groundwater and the proposed Uranium Mill Tailings Radiation Control Act [a potential ARAR (40 CFR 192)] guideline, probably because the shallow wells are in an area of known subsurface contamination. However, all measured values have been relatively consistent over the years and between wells, which could suggest that no horizontal migration of radionuclides in groundwater is occurring.

Air investigations. Radon-222 levels are measured quarterly as part of the environmental monitoring program. Since 1984, radon levels have fluctuated some in all locations but one; however, they have remained below the DOE guideline of 3.0 pCi/L for uncontrolled sites (DOE 1990a). In several instances, however, the Missouri radon limit of 1 pCi/L [19 Code of State Regulations (CSR) 20] has been exceeded. Radon concentrations along the northern boundary of the property are heavily influenced by soil moisture and the presence or absence of standing water in the ditch abutting the fenceline. Standing water could account for lower radon-222 levels during some years, and dry conditions could cause higher readings at other times. Annual averages are given in Table 2-39.

SLAPS Vicinity Properties

The SLAPS vicinity properties include Banshee Road; ditches to the north and south of SLAPS; a portion of the property south of SLAPS owned by the St. Louis Airport Authority; the City of St. Louis property to the north of SLAPS, known as the ball field area; the haul roads and vicinity properties; Coldwater Creek and vicinity properties; and the Norfolk and Western Railroad properties. The locations of these properties are shown in Figures 2-36, 2-37, and 2-38. Radiological characterization of these properties was necessary to define the magnitude and boundaries of contamination and evaluate disposal alternatives.

Banshee Road. Forty-eight boreholes were drilled through Banshee Road, which forms the southern boundary of SLAPS, during the radiological characterization. Downhole gamma logging was performed in 47 of these boreholes to determine the general depth of contamination from gamma-emitting radionuclides. Gamma logging was conducted by lowering an unshielded NaI(Tl) detector into the hole and recording the count rate as a function of depth. No significant variations in count rates were observed as gamma logging progressed in the boreholes. Downhole gamma logging data were used for selection and analysis of soil samples to determine radionuclide concentrations. Analytical results for soil revealed two small areas with elevated concentrations of thorium-230 to a depth of 0.3 m (1 ft) (Figure 2-39). Concentrations of uranium-238, radium-226, thorium-232, and thorium-230 range from 1 to 46, 0.8 to 7, 0.6 to 7, and 0.4 to 34 pCi/g, respectively (BNI 1990b).

Ditches to the north and south of SLAPS. In 1982 BNI performed a radiological survey of the drainage ditches and portions of Coldwater Creek to establish the vertical and horizontal limits of uranium-238 and radium-226 contamination (BNI 1983). In 1986 a radiological investigation of the SLAPS ditches was conducted to determine the depths and areal limits of radioactive contamination. Near-surface gamma radiation measurements were taken at the SLAPS ditches to identify areas with radionuclide concentrations exceeding DOE guidelines. Eighty-six subsurface and 125 surface locations were sampled at the property. Downhole gamma logging was performed in the augered holes and boreholes to determine the general depth of gamma-emitting radionuclides. Significant variations in count rates at ten

locations were observed as gamma logging progressed at the SLAPS ditches, indicating contamination from gamma-emitting radionuclides. Analytical results for soil revealed areas with elevated concentrations of radium-226 and thorium-230 in surface and subsurface samples. Essentially all the ditch area north and south of SLAPS is contaminated; contamination ranges in depth from 0 to 4.3 m (0 to 14 ft) (see Figure 2-40). The 4.3-m (14-ft) depth of contamination occurred at one location. Thorium-230 was identified as the major contaminant. Concentration ranges of uranium-238, radium-226, thorium-232, and thorium-230 are less than 1 to 94, 0.7 to 130, 0.7 to 6, and 0.9 to 15,000 pCi/g, respectively (BNI 1990b).

St. Louis Airport Authority property. A portion of the property owned by the St. Louis Airport Authority was surveyed to determine the areal and vertical extent of radioactive contamination to the south of SLAPS. Seventy surface and 65 subsurface locations were characterized for radioactive contamination. Near-surface gamma radiation measurements were taken, and downhole gamma logging was performed in the boreholes. No significant variations in count rates were observed as gamma logging progressed. Soil samples were collected and analyzed for radioactive constituents; analytical results indicate that radioactive contamination on the airport property south of SLAPS extends to a depth of 1.2 m (4 ft) at two locations. Several areas on the airport property exhibit radioactive contamination. In general, the contamination on this property is shallow [0.6 m (2 ft)] and extends the length of SLAPS. Analytical results for soil revealed areas with elevated concentrations of thorium-230 in surface samples. All uranium-238 concentrations are less than 11 pCi/g. Concentrations of radium-226, thorium-232, and thorium-230 range from 0.8 to 3.3, 0.8 to 5, and less than 0.7 to 58 pCi/g, respectively. Figure 2-41 shows areas and depths of contamination at the Airport Authority property (BNI 1990b).

Ball field area. This property north of SLAPS is leased to the City of Berkeley by the City of St. Louis. Near-surface gamma radiation measurements were taken, and downhole gamma logging was performed in the augered holes. No significant variations in count rates were observed as gamma logging progressed in the augered holes. Approximately 680 soil samples were collected from the ball field area; analytical results revealed areas with elevated concentrations of radium-226 in surface samples and thorium-230 in surface and subsurface

samples. Based on soil sampling results for the ball field, radioactive contamination averages 0.3 m (1 ft) in depth over the first 45.7 to 61 m (150 to 200 ft) along the northern edge of McDonnell Boulevard (Figure 2-42). Thorium-230 was identified as the primary contaminant. The infield areas of the ball fields showed no contamination. Concentrations of uranium-238, radium-226, thorium-232, and thorium-230 range from less than 3 to 42, less than 5 to 190, 0.6 to 5, and less than 0.1 to 200 pCi/g, respectively (BNI 1990b).

Haul roads and associated vicinity properties. In December 1984, ORNL conducted a mobile gamma scanning survey of potential transportation routes to and from the Latty Avenue Properties and West Lake Landfill (ORNL 1985). Preliminary surveys conducted along these roads showed no radionuclide concentrations in excess of DOE guidelines for surface soil. In addition, ORNL conducted a mobile gamma scan on the haul roads between SLAPS and the Latty Avenue Properties. Anomalies were detected on McDonnell Boulevard, Hazelwood Avenue, and Pershall Road. BNI conducted additional sampling along these roads and Latty Avenue, Eva Avenue, and Frost Avenue to detect the presence of radionuclides exceeding DOE guidelines; analytical results showed thorium-230 to be the major contaminant (BNI 1990b). Radiological characterization included collecting soil samples from the shoulders of the haul roads and approximately 45.7 m (150 ft) onto adjacent properties bordering these roads. Samples from underneath the pavement were collected from Pershall Road, McDonnell Boulevard, and Latty Avenue. In addition to discrete samples, composite samples were collected and considered contaminated if activity for any radionuclide was greater than 2 pCi/g. Soil samples were composited as an initial step to determine whether the shoulders of the haul roads were contaminated. A summary of the characterization results is given in Table 2-40. Because only properties adjacent to Eva Avenue and Frost Avenue (not the roads themselves) were characterized, they are not included in Table 2-32. In general, radioactive contamination is present in some areas under Latty Avenue, McDonnell Boulevard, and Pershall Road and along both sides of Hazelwood Avenue, Pershall Road, and Eva Avenue. Contamination is primarily on the northern side of Frost Avenue. Figure 2-43 shows areas of contamination at the haul roads. Summary results for the haul roads include the following:

- Latty Avenue Of 954 samples analyzed, no results showed concentrations of uranium-238 greater than 50 pCi/g; 1 sample showed radium-226 greater than 5 pCi/g; no result for thorium-232 was greater than 5 pCi/g; and of the 1,006 samples analyzed for thorium-230, concentrations in 82 were greater than 5 pCi/g (BNI 1990b).

- McDonnell Boulevard Of 354 samples analyzed, only 5 showed uranium-238 concentrations greater than 50 pCi/g; only 25 (including composites) showed radium-226 concentrations greater than 5 pCi/g; only 6 had thorium-232 concentrations greater than 5 pCi/g; and 118 (including composites) showed thorium-230 concentrations greater than 5 pCi/g (BNI 1990b).

- Pershall Road Of 900 samples analyzed, only 6 had concentrations of uranium-238 greater than 50 pCi/g; 95 contained radium-226 concentrations greater than 5 pCi/g, and 15 were greater than 15 pCi/g; 12 showed concentrations of thorium-232 greater than 5 pCi/g; and 261 had concentrations of thorium-230 greater than 5 pCi/g (BNI 1990b).

- Hazelwood Avenue Of 122 samples analyzed, 2 had concentrations of uranium-238 greater than 50 pCi/g; 18 showed concentrations of radium-226 greater 5 pCi/g, and 4 were greater than 15 pCi/g; only 1 exceeded 5 pCi/g for thorium-232; and 59 exceeded 5 pCi/g for thorium-230 (BNI 1990b).

Neither walkover gamma scans were performed nor near-surface gamma radiation measurements were taken at the 67 haul roads vicinity properties because thorium-230, an alpha radiation emitter previously identified as the major contaminant, cannot be detected with field instruments. Soil samples taken from Properties 12, 35, 37, 38, 39, 57, and 58 were analyzed for uranium-238, radium-226, and thorium-232 in addition to the thorium-230 analysis done for all of the haul roads vicinity properties. From these seven properties, none of 475 samples showed uranium-238 greater than 50 pCi/g, only 4 showed radium-226 concentrations greater than 5 pCi/g, and none showed thorium-232 concentrations greater than 5 pCi/g (BNI 1990b). For this reason, only thorium-230 analyses were conducted on

the other vicinity properties. For confirmation, during remedial action, soil samples will be collected from all the vicinity properties exhibiting above-guideline thorium-230 concentrations and will be analyzed for gamma-emitting radionuclides.

Soil samples were collected in 0.3-m (1-ft) increments to a depth of 1 m (3 ft) at 15-m (50-ft) grid intersections at the haul roads' edges, 15 m (50 ft) onto the vicinity properties, and at 30.5-m (100-ft) grid intersections 45.7 m (150 ft) onto the properties from the edge of the road (Figure 2-44). Areas and concentrations of thorium-230 contamination are shown in Table 2-41.

Properties 1 through 14A border McDonnell Boulevard. Contamination is generally confined to areas immediately adjacent to the boulevard and is generally shallow. Only Properties 12, 13, and 15 show elevated concentrations (exceeding DOE remedial action guidelines) of thorium-230 (less than 0.5 to 570 pCi/g). Property 12 also shows elevated radium-226 concentrations.

Properties 16, 17, and 19 near Eva Avenue have low levels of thorium-230 contamination. One isolated area of contamination, extending to a depth of 1.5 m (5 ft), exists near the intersection of McDonnell Boulevard and Eva Avenue.

Properties 20 through 31 are located along Frost Avenue. Areas of contamination are more numerous on the northern side of the avenue; specifically, Properties 21 through 24 show maximum thorium-230 concentrations from 110 to 710 pCi/g. In general, contamination is shallow [0 to 0.3 m (0 to 1 ft)]. Properties bordering Hazelwood Avenue show shallow [less than 0.7 m (less than 2 ft)] contamination. However, Properties 32 through 48 have maximum thorium-230 concentrations ranging from 53 to 1,200 pCi/g. Properties 49 through 63A show spotty contamination that is shallow and immediately adjacent to the road.

In summary, radioactive contamination is present in some areas underneath Latty Avenue, McDonnell Boulevard, and Pershall Road, and on both sides of Hazelwood Avenue, Pershall Road, and Eva Avenue. Contamination is primarily located on the northern side of Frost Avenue (BNI 1990b).

Coldwater Creek and vicinity properties. Surface soil and sediment samples [from 0 to 15 cm (0 to 6 in.)] from the sides (at the edge of the water) and center of Coldwater Creek, beginning at SLAPS and continuing downstream to HISS, were collected at 30.5-m (100-ft) intervals and analyzed in 1986. The data from these analyses indicate spotty contamination over the entire distance. Analytical results for sediment reveal areas with elevated concentrations of thorium-230 ranging from 0.5 to 110 pCi/g. Uranium-238, radium-226, and thorium-232 concentrations are low and range from 0.2 to 4.8, 0.3 to 3.1, and less than 0.1 to 1.5 pCi/g, respectively.

Results from the 1987 Coldwater Creek characterization indicate areas with elevated radium-226 and thorium-230 concentrations; radium-226 concentrations range from 0.6 to 71 pCi/g, and thorium-230 concentrations range from 0.8 to 5,100 pCi/g. Uranium-238 and thorium-232 concentrations range from less than 2 to 78 and 0.7 to 5 pCi/g, respectively. All samples were collected from the center of the creek (where accessible), 30.5 m (100 ft), and 61 m (200 ft) to the east and west of the centerline of the creek at 30.5-m (100-ft) intervals from the southwestern corner of SLAPS to Pershall Road; the samples were collected from bank sediments and private properties in the floodway. Samples were collected from depths of 0 to 15 cm (0 to 6 in.) and 15 to 30 cm (6 to 12 in.). Contamination along the edges and centerline of Coldwater Creek is shown in Figure 2-45; this figure was compiled from data from the 1986 and 1987 characterization and illustrates areas that exceed the DOE surface soil guideline of 5 pCi/g for thorium-230.

In 1989 additional Coldwater Creek characterization included collection and analysis of soil samples from the banks at the edge of the creek for a distance of 2.4 km (1.5 mi) north of Pershall Road. Soil samples were collected from both sides of the creek at 30.5-m (100-ft) intervals for the first 0.8 km (0.5 mi) and at 61-m (200-ft) intervals for 1.6 km (1 mi) thereafter. Sixty-four of 175 samples exhibited radionuclide concentrations

exceeding DOE remedial action guidelines. Also in 1989, a 7.7-km (4.8-mi) stretch of Coldwater Creek was surveyed for the Corps of Engineers beginning at the termination point of the 2.4-km (1.5-mi) study. Soil samples were collected at 152.4-m (500-ft) intervals and analyzed; results reveal areas with above-guidelines concentrations of thorium-230 in surface samples.

Additional sediment sampling has been conducted in Coldwater Creek as part of the ongoing environmental programs at HISS and SLAPS. (Results are discussed in the sediment subsections for HISS and SLAPS.) The primary radioactive contaminant at Coldwater Creek is thorium-230; contamination along the creek is spotty and confined to surface soil and sediment. Areas of contamination are more numerous between SLAPS and Pershall Road, adjacent to SLAPS and HISS. There is a correlation between the creek's configuration and the areas of contamination: the inside banks of the creek at the bends appear to be the areas containing above-guideline concentrations of thorium-230, indicating settling of contaminated sediment.

The locations of the vicinity properties adjacent to Coldwater Creek are shown in Figure 2-38. Results of the most recent characterization activities on these properties are given in Table 2-42 (BNI 1990b). Properties 1, 2, 3, 5, 8, and 9 exhibit thorium-230 concentrations in excess of DOE remedial action guidelines, primarily in the first foot of soil.

Railroad properties. Table 2-43 gives the 1986-1989 characterization results for the Norfolk and Western Railroad properties. Near-surface gamma radiation measurements were not taken on the railroad properties adjacent to Hazelwood Avenue, Eva Avenue, Coldwater Creek, or Hanley Road because thorium-230 had already been identified as the primary contaminant. Analytical results for soil collected from these properties revealed radioactive contamination on portions of all the railroad properties except for the one adjacent to Hanley Road and Hazelwood Avenue, north of Latty Avenue. The areas and depths of radioactive contamination on the railroad properties are shown in Figures 2-46 through 2-49.

Hazelwood Interim Storage Site

In 1981 Oak Ridge Associated Universities (ORAU) characterized the storage pile at HISS and performed a radiological survey of the northern and eastern boundaries of the property. Elevated concentrations of members of the naturally occurring uranium, thorium, and actinium decay series were found in the storage pile. Levels of contamination (principally thorium-230) similar to those on the property were also found on both boundaries (ORAU 1981).

Soil survey. During fall 1986, a radiological survey was conducted by BNI and Thermo Analytical/Eberline (TMA/E) at HISS. Thirty-six boreholes were drilled; soil samples were collected and analyzed for uranium-238, radium-226, thorium-232, and (in selected samples) thorium-230. Table 2-44 summarizes the results of this survey. Experience in the St. Louis area has shown that when the radium-226 concentration is elevated, it is reasonable to assume that the concentration of thorium-230 exceeds the DOE guideline of 15 pCi/g. Based on this rationale, as well as on the downhole gamma logs, samples were selected for thorium-230 analysis. Typically, this meant that samples were selected from regions of the borehole where gamma logging results showed a decrease in the count rate, indicating a drop in radium-226 concentration. Radiological characterization results revealed that a majority of the ground surface is contaminated at levels exceeding DOE guidelines. Contamination was found to a depth of 1.8 m (6 ft); the average depth is approximately 1 m (3 ft). Areas and depths of contamination at HISS are shown in Figure 2-50 (BNI 1987b). The volume of contaminated soil at HISS, including the material in stockpiles, is 53,520 m^3 (70,000 yd^3).

Additional information about radiological conditions at HISS has been obtained through the DOE environmental monitoring program conducted by BNI since 1984. The monitoring includes quarterly monitoring of external gamma radiation exposure; annual average rates are listed in Table 2-45. External gamma radiation exposure rates have declined sharply since 1984 at all but two monitoring locations; this overall decline reflects remedial actions at the property (BNI 1989c).

Surface water and sediment survey. The environmental monitoring program includes quarterly collection of sediment samples from surface water sampling locations where sediment is present (Table 2-46). All sediment samples taken after 1984, with the exception of four (locations 2, 3, 6, and 7 for thorium-230 and location 2 for radium-226 on one occasion), were below DOE guidelines for residual radioactivity in surface soil. Locations of sampling and monitoring points are shown in Figure 2-51.

Surface water samples were collected quarterly from sampling locations established on the basis of potential contaminant migration and discharge routes from HISS. Upstream locations were chosen to establish background conditions, and downstream locations were chosen to determine the effect of runoff from HISS on surface waters in the vicinity. Annual average results for surface water monitoring from 1984 to 1989 are given in Table 2-47. Concentrations of uranium in surface water in the vicinity of HISS have declined substantially since 1984, which reflects the effects of remedial action at the property, primarily the covering of the storage pile with a synthetic, low-permeability membrane. Concentrations of radium-226 are low and have remained almost unchanged. Overall, thorium-230 concentrations are low and have been relatively stable over the six-year period.

Groundwater investigations. Groundwater samples have also been collected quarterly from seven of the monitoring wells established along the perimeter of the property (Figure 2-52) and from two background wells established on the basis of available hydrogeological data. Results of groundwater analyses from 1984 through 1989 are presented in Table 2-48. Here, as at SLAPS, several wells exhibit uranium concentrations greater than those occurring naturally in groundwater. A steady rise in total uranium concentrations in well HISS-6 has been noted since 1986 (33 to 82.1 pCi/L). Analytical data for total uranium in HISS-6 in 1990 shows a drop to 50.1 pCi/L; monitoring continues. In the future, water samples will be analyzed for both dissolved and suspended uranium to determine whether the uranium reached the groundwater via attachment to sediment particles or through infiltration of surface water. However, since new wells were installed in 1985, most measured values have been relatively consistent between wells, suggesting that no horizontal movement of radionuclides in groundwater is occurring.

Air investigations. Environmental monitoring at HISS also includes quarterly sampling of radon-222; annual averages are listed in Table 2-49. There have been no notable trends in radon concentrations at HISS since 1984. All values are below state regulatory levels and the DOE guideline of 3 pCi/L (DOE Order 5400.5, Section III). Overall, concentrations have remained relatively stable.

Futura Coatings

Characterization of Futura Coatings began in 1986 and was conducted in two phases. Phase I consisted of establishing four environmental monitoring stations inside the buildings. Phase II characterization supported the finding of the 1977 ORNL survey that thorium-230 is the principal radioactive soil contaminant at Futura, although analysis also revealed elevated levels of radium-226, uranium-238, and thorium-232.

Building survey. Characterization of the interior and exterior surfaces of the buildings indicates that there is no nonremovable or removable contamination exceeding DOE guidelines (BNI 1987e).

Soil survey. The maximum concentrations of thorium-230, radium-226, uranium-238, and thorium-232 in the soil samples analyzed are 2,000, 2,300, 2,500, and 26 pCi/g, respectively. Gamma logging data and analytical results for subsurface soil show that contamination exists at depths ranging from the surface to more than 4.6 m (15 ft) below the surface. The volume of contaminated soil at Futura is 26,000 m^3 (34,000 yd^3). Characterization data are summarized in Table 2-50 (BNI 1987c); areas and depths of contamination at Futura are shown in Figure 2-53.

Air investigations. Two thermoluminescent dosimeters installed in September 1986 were recovered and analyzed during the exchange of detectors in January 1987. Calculated radiation doses inside the buildings range from 2 to 22 mrem/yr above natural background. Continuous exposure for one year was assumed in calculating the radiation dose. The DOE radiation protection standard for external radiation is 100 mrem/yr in excess of natural background levels.

Four Track-Etch radon detectors installed in September 1986 were recovered and analyzed during the exchange of detectors in January 1987. The results show radon concentrations inside the buildings to range from 0.3 to 0.7 pCi/L and average 0.6 pCi/L. The DOE guideline for radon-222 is 3 pCi/L. Radon levels comparable to those measured inside the Futura buildings are typically found in outdoor areas where natural radium is present; results, therefore, indicate minimal intrusion of radon gas into the plant buildings.

Air particulate samplers were established inside the Futura buildings to determine gross alpha concentrations; 50 air particulate filter samples were collected and analyzed. Gross alpha concentrations range from less than 0.001 to 0.004 pCi/m^3. The DOE guideline is 0.04 pCi/m^3 for the maximum thorium-230 concentration in air in uncontrolled areas (lung retention class W) (DOE 1990a).

Latty Avenue Vicinity Properties

Radioactive contamination is present on all six Latty Avenue vicinity properties (Figure 2-4), and thorium-230 was identified as the major contaminant. Depths of contamination range from the surface to 4.3 m (14 ft) at one location on Property 1, but contamination is typically confined to the top 1 m (3 ft) of soil. In general, the areas of contamination are smaller and fewer as distance from HISS and Latty Avenue increases. The ranges of uranium-238, radium-226, thorium-232, and thorium-230 contamination on the six properties are given in Table 2-51; areas and depths of contamination are shown in Figures 2-54 through 2-59.

2.4.3 Chemical Conditions

Chemical sampling and analysis at the St. Louis site were conducted to meet one or a combination of the following objectives: (1) to identify and quantify the contaminants present, (2) to determine whether the material is classified as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) by analyzing for RCRA-hazardous waste characteristics, (3) to assess the potential health hazards from this material to workers performing remedial action activities so that proper design and implementation of a health

and safety plan is possible, and (4) to define chemical characteristics, investigate some of the potential migration pathways, and determine any resulting impact on the design criteria for final disposal of the waste.

The planned field activities were completed based on the objectives of the characterization and the information obtained from scoping activities. These activities provided information needed to evaluate the chemical characteristics of the waste. The following types of analyses were completed for samples collected from the properties: metals, mobile ions, organics, and RCRA characteristics.

Aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc were measured in all soil and water samples. During Phase I, analysis was conducted for mercury in soil at SLDS. Because extraction procedure (EP) toxicity analyses for the presence and leachability of mercury had already been performed, this testing was not conducted during Phase II. Metals were chosen for analysis because of their presence in the uranium ores used in the process that produced the residues; barium was specifically targeted because it was used in the process as a coprecipitator of sulfates and radium. Previous limited chemical characterization of SLAPS showed the presence of metals in excess of background concentrations.

Because of their use in uranium processing at SLDS, mobile ion concentrations (including sulfate, fluoride, and nitrate) were determined for soil and water samples. Also, because of their negative charge, these ions will not bind to negatively charged clay particles. Therefore, the presence of the ions in concentrations exceeding background levels may indicate that waste is migrating from its source.

Priority pollutant organics, including volatiles and semivolatiles, were analyzed in soil and water samples to define the organic constituents in the waste.

Samples were tested for RCRA characteristics (ignitability, reactivity, corrosivity, and leachability for lead, silver, barium, chromium, arsenic, cadmium, mercury, selenium, and several pesticides) to determine whether the waste exhibits hazardous characteristics.

Water samples were analyzed for total organic halides (TOX), total organic carbon (TOC), pH, and specific conductance in accordance with accepted EPA protocol. These parameters are checked to monitor changes in organic and inorganic composition, which is indicative of groundwater quality, and they are used as indicators to determine the need for further chemical sampling. A change in the acidity or basicity (pH) affects the solubility and mobility of chemical contaminants. Specific conductance measures the capacity of water to conduct an electrical current, and it generally increases with elevated concentrations of dissolved solids. TOC and TOX are indicators of the organic content of water: TOC measures the total organic carbon content of water but is not specific to a given contaminant, and TOX measures organic compounds containing halogens.

Chemical sampling locations were selected in both a biased and random manner. Biased locations were sampled in alternating 0.6-m (2-ft) intervals at SLAPS; the samples were analyzed for RCRA characteristics, volatile organics, semivolatiles, and metals. At Futura and HISS, samples were taken at 0.3- to 0.6-m (1- to 2-ft) intervals within the known boundaries of radioactive contamination. Random borehole samples were analyzed for volatiles, semivolatiles, metals or mobile ions, and RCRA characteristics. An additional sample per random hole was collected from below the radioactive waste to determine whether any chemical contamination had migrated outside the boundaries of the radioactive contamination. Analyses for volatile organics, semivolatiles, and metals or mobile ions were performed on these samples.

Chemical constituents in groundwater at SLAPS were monitored in 16 wells for 5 quarters in 1988 and 1989. At the Latty Avenue Properties, chemical constituents were monitored in eight wells for five quarters, also in 1988 and 1989. For characterization at SLDS, eight wells were monitored for four quarters. Samples from SLAPS, SLDS, and Latty Avenue Properties were analyzed for volatile and semivolatile organics and metals. SLDS groundwater was also analyzed for pesticides and polychlorinated biphenyls (PCBs).

Currently available chemical data are summarized in the following subsections; they were compiled from various published and draft reports, as referenced.

St. Louis Downtown Site

Chemical characterization of soil was completed in two phases. In Phase I, 59 of the 109 boreholes were sampled and analyzed to determine the presence or absence of chemicals and to get a general indication of chemical distribution in relation to radioactive constituents. Soil samples were composited for analysis of metals, semivolatile organics, and RCRA-hazardous waste characteristics. Forty discrete samples from 23 boreholes were collected for analysis of volatile organics. In Phase II, 51 boreholes were sampled for chemical constituents to further define chemical distribution. During Phase II, discrete samples were submitted for analyses of metals and RCRA characteristics. Seven composite samples taken from the ground surface down to undisturbed soil were collected and analyzed for RCRA-hazardous waste characteristics. Figure 2-60 shows the locations of chemical boreholes.

Thirteen volatile organic compounds (VOCs) were detected in 20 of the 23 boreholes. Toluene was found in 31 of 40 samples, chloroform and trichlorofluoromethane in 12 of 40 samples, and methylene chloride in 11 of 40 samples. In general, concentrations of compounds detected were low, with mean concentrations ranging from 2.0 to 73 ppb. Table 2-52 shows the analytical results for VOCs in soil at SLDS during Phase I. No VOC analyses were conducted during Phase II because the average concentrations of VOCs detected in Phase I were low, none of the compounds detected are believed to be associated with MED/AEC activities, and the objectives of Phase I were met.

One composite sample each was collected and analyzed for base/neutral and acid extractable (BNAE) compounds from 56 of the 109 boreholes drilled during Phase I. BNAE analysis is an analytical tool for investigating semivolatile constituents that are partitioned into organic solvents and are amenable to gas chromatography. Extensive use of BNAE has been applied for investigative efforts regarding the semivolatile fraction of EPA's Target Compound List (TCL); the primary instrument used for analysis is the gas

chromatography/mass spectrometry data system. Twenty-seven BNAE compounds were detected; all but nine were polynuclear aromatic hydrocarbons (PAHs), which are typically found in coal, coal products, or coal breakdown residues (Swann and Eschenroeder 1983, BNI 1990a). A coal-fired boiler and a coal stockpile are located on the property. Past disposal methods for the fly ash and slag generated are unknown, and other residues resulting from coal combustion or storage may have contributed to the distribution of PAHs at SLDS. Semivolatile compounds other than PAHs range from 660 ppb to 14,900 ppb. Of the PAHs, fluoranthene exhibits the highest concentration (300,000 ppb). Phenanthrene, benzo(a)pyrene, and chrysene occur in the next highest concentrations. Table 2-53 lists summary statistics for BNAE organics detected in soil.

Analytical results for metals in soil are presented in Tables 2-54 and 2-55 for Phase I and Phase II, respectively. Concentrations of the following metals exceed the maximum expected background levels for natural soil: antimony, arsenic, barium, boron, cadmium, chromium, cobalt, copper, lead, magnesium, manganese, mercury, molybdenum, selenium, silver, sodium, thallium, and zinc. In general, these metals were found in comparable levels in composite and discrete samples collected in Phases I and II; however, chromium, cobalt, sodium, and manganese were present in excess of expected background concentrations (at very low concentrations) in Phase II but were absent in Phase I. Most metals exceeding expected background concentrations were found at depths of less than 1.8 m (6 ft), but selenium and thallium appear at depths as great as 5.5 to 6 m (18 to 20 ft).

Of the eight metals analyzed for EP toxicity (lead, silver, barium, chromium, arsenic, cadmium, mercury, and selenium), only a limited number of samples failed the test for lead. Soil samples were also tested for ignitability, reactivity, and corrosivity; no samples failed these tests. Results from Phase I indicate that three very small, isolated areas exist where soil fails the hazardous waste criterion for EP toxicity-lead (boreholes B16C02, B16C30, and B16C37). Therefore, it appears that most metals at SLDS are unlikely to leach from soil to groundwater.

In all likelihood, the materials will not have to be handled as hazardous wastes when excavated because current procedures allow averaging of analytical results obtained from a waste matrix. Before final remedial action begins, the extent of contamination from lead or other metals will be confirmed using the toxicity characteristic leaching procedure (TCLP), which replaced the EP toxicity test. In general, there are chemical contaminants in the form of metals at the St. Louis site, and PAH compounds have been detected at elevated levels at SLDS.

Groundwater monitoring for chemical indicator parameters (pH, specific conductance, TOX, and TOC) was conducted for four quarters to reveal possible changes in the inorganic and organic composition of the groundwater. Fluoride and nitrate samples were collected and analyzed for one quarter. Groundwater was also analyzed for VOCs, BNAEs, pesticides, and PCBs.

Ten organic compounds were detected in wells at SLDS; benzene was the most frequently found (in 6 of 24 samples) but is not believed to have been a component of uranium processing conducted for MED. Table 2-56 is a one-year summary of organics detected at SLDS, and Table 2-57 lists results for water quality parameters for each well.

The majority of the organic groundwater contaminants appear consistently in well B16W03S (7 of 10 organics detected were found in this well); 17 of the 25 positive values detected for all samples were from this well (Table 2-58). Dimethyl ether was detected as a tentatively identified compound, which means that it is probably present but its concentration is uncertain. Dimethyl ether was used in uranium processing at SLDS during MED/AEC activities, but its presence is probably not the result of MED/AEC activities because it is a volatile compound that would long since have dissipated. It is not a hazardous waste, and its presence will not affect engineering design for remedial action.

Sixteen metals were detected in groundwater (summarized in Table 2-59). Both calcium and sodium were found in all samples analyzed. Boron, magnesium, and manganese were detected in 31 of 32 samples analyzed, and potassium and zinc were detected in 29 of 32. Thallium and lead were completely absent at levels above the detection limit.

Metals associated with uranium ores (arsenic, barium, nickel, and selenium) were generally present in concentrations of 100 to 700 μg/L. Cadmium, chromium, and copper (also associated with uranium ores) were detected at much lower concentrations. With the exception of zinc, those metals detected most frequently in soils (thallium, selenium, mercury, cadmium, lead, and zinc) were not frequently found above detection limits in groundwater.

St. Louis Airport Site

Soil samples at SLAPS were collected from biased and randomly selected locations (Figure 2-61). Biased locations were selected based on historical information regarding MED/AEC activities, radiological data obtained from previous characterizations, and current site conditions. Biased sampling locations were first selected from locations where radiological boreholes had been drilled previously; samples from these locations were analyzed for RCRA-hazardous waste characteristics, metals, VOCs, and BNAEs.

One sample per hole was taken from beneath the maximum depth of radioactive contamination and analyzed for VOCs, metals, and semivolatiles. In some instances, random sampling locations were the same used for boreholes in previous radiological sampling. Samples from at least two intervals per borehole were randomly selected and analyzed for VOCs, BNAEs, and metals. The entire depth of the hole in the area of radioactive contamination was composited and tested for RCRA-hazardous waste characteristics in 22 boreholes. Twenty-two and eight boreholes were drilled in random and biased locations, respectively; 109 soil samples were submitted for analysis. Table 2-60 shows which analyses were performed on samples from given depth intervals in the biased and random sampling locations.

Three VOCs exceeding detection limits were found in 37 of 90 soil samples submitted for analysis. The concentrations of these compounds (with the exception of toluene) are very low, in the ppb range. The VOCs are generally unevenly distributed at the property; however, toluene was consistently found in borings from the eastern portion of the property. None of those compounds is believed to have been used during uranium processing. Toluene

was found in 26 of the samples at concentrations ranging from 1.5 to 1,200 ppb. Trichloroethene was found in six samples at concentrations ranging from 1.6 to 15 ppb. Trans-1,2-dichloroethene was found in five samples at concentrations ranging from 1.3 to 7.7 ppb (BNI 1990e).

Fifty-two of the 90 soil samples contained BNAEs (BNI 1990e).

Analytical results for metals in soil are summarized in Table 2-61; 15 metals are present at concentrations exceeding background levels. Sample results were compared with a range of background metal concentrations for soils, as was done at SLDS. Cadmium, molybdenum, and selenium were detected in all samples at concentrations exceeding background. Barium exceeded the background level in 5 of the 90 samples, but these 5 samples were collected from an area of known barium sulfate cake disposal (BNI 1990e).

Most of the metals found at levels greater than the detection limit appear to be confined to near-surface depths [0 to 2 m (0 to 6 ft)]. Magnesium was detected as deep as 6.7 m (22 ft), which is below the depth of radioactive contamination [down to 5.5 m (18 ft)] previously defined at locations from which biased samples were collected. Magnesium, cadmium, molybdenum, nickel, cobalt, copper, lead, zinc, arsenic, selenium, and barium were detected within the known boundaries of radioactive wastes in these same boreholes. At the random borehole locations, radioactive contamination was detected at depths between 0.15 and 5.5 m (0.5 and 18 ft). Arsenic, cadmium, cobalt, copper, molybdenum, chromium, lead, antimony, zinc, magnesium, barium, nickel, and selenium were detected within the radioactive waste. Magnesium, cadmium, and cobalt were detected in the sample obtained from a depth greater than 5.5 m (18 ft) (BNI 1990e).

Biased samples taken from within the radioactive waste and composite samples from random boreholes were tested for RCRA-hazardous waste characteristics. All samples were below the criteria for reactivity, ignitability, corrosivity, and toxicity.

Soil sample analyses were performed for the mobile ions fluoride, nitrate, and sulfate, selected for analysis because they were present in material used to process uranium ore. SLAPS has sulfate residues with a content of 860 ppm; the background value is 610 ppm. Fluoride was slightly higher than background (1.2 to 31 ppm) in four samples that range from 32.4 to 62.9 ppm (BNI 1990e).

Chemical indicator parameters (pH, specific conductance, TOC, and TOX) were monitored in groundwater to reveal possible changes in inorganic and organic composition. Results indicate groundwater of poor quality (Table 2-62) (BNI 1988a, 1989a, 1990c). Groundwater was analyzed for metals to determine whether metals present in the original uranium ore had leached into the groundwater. The same sixteen metals detected in soil samples obtained from the property were found in groundwater.

Calcium, sodium, and beryllium were found in all 32 samples analyzed. Boron, magnesium, and manganese were each detected in 31 of 32 samples, and potassium and zinc were detected in 29 of 32. Except for magnesium and barium, those metals detected most frequently in soil (magnesium, cobalt, cadmium, molybdenum, copper, barium, and lead) were not found frequently in groundwater at levels greater than the detection limit. Thallium and lead were completely absent in groundwater at levels greater than the detection limit. Metal statistics are summarized in Table 2-63 (BNI 1989a, 1990c).

In January 1989, analyses were performed for priority pollutant organics, including 36 VOCs, 65 BNAEs, and 27 pesticides and PCBs. Five organic compounds were detected at low concentrations: the pesticide Endosulfan F, 1,2-dichloroethene, trichloroethene, toluene, and bis(2-ethylhexyl)phthalate. Table 2-64 provides analytical results for organic chemical constituents present in detectable quantities. (Monitoring well locations at SLAPS are shown in Figure 2-33).

SLAPS Vicinity Properties

The ball field area was characterized to identify chemical contaminants associated with the demolition-generated fill material covering the property and to identify pathways for

migration of chemical or radioactive contaminants. Samples from 11 boreholes at locations chosen to characterize subsurface conditions and construction-related wastes reportedly buried in the area were analyzed for chemical constituents. Samples were collected 0.6 m (2 ft) into undisturbed soil at randomly selected intervals. At least two intervals per borehole were sampled and analyzed for metals, mobile ions, VOCs, and BNAEs. A composite sample from each borehole was analyzed for RCRA-hazardous waste characteristics, pesticides, and PCBs. Chemical sampling locations are shown in Figure 2-62.

Samples from 10 of 11 boreholes contain toluene and 1,1,1-trichloroethene. Two areas are defined by higher concentrations of toluene: all locations north of Coldwater Creek have toluene in concentrations ranging from 13 to 48 ppb; the other area, the center of the ball field, has concentrations ranging from 12 to 29 ppb. Toluene was detected at every location with the exception of Borehole C43 (see Figure 2-62). Locations and depths of volatile organic contamination are listed in Table 2-65 (BNI 1989b).

Samples submitted for metals analysis contained nine metals at concentrations exceeding background levels; these metals are most prevalent at depths ranging from 1.5 to 3 m (5 to 10 ft). Guidelines used to determine whether soil samples contain unusual concentrations of metals and mobile ions were obtained from two sources: analytical results for mobile ions in soil samples taken in the surrounding area, and average concentration ranges for metals in soils at various locations, primarily in the United States. Table 2-66 lists the summary statistics for each metal found at the ball field area at concentrations exceeding background levels (BNI 1989b). These results are consistent with information that the area was previously used as a landfill (AEC 1960).

Thirty-three samples were analyzed for the mobile ions sulfate, nitrate, and fluoride as indicators of contaminant migration. Only one sample contained sulfate in excess of background levels.

A composite sample was taken from each of the 11 boreholes and analyzed for RCRA-hazardous waste characteristics and pesticides/PCBs. None of these samples failed the RCRA tests. No PCBs were detected, and only one pesticide (Dieldrin) at very low

levels (230 ppb) was detected. No additional sample analysis was conducted on other vicinity properties because only low concentrations of chemicals were detected at SLAPS (BNI 1989b).

Four sediment samples were also collected along Coldwater Creek for chemical analysis. The first was just north of Banshee Road, the second just north of McDonnell Boulevard, the third just south of the Latty Avenue Properties, and the fourth downstream of the Latty Avenue Properties. Metals analyses showed cadmium, magnesium, molybdenum, selenium, thallium, and zinc in excess of maximum expected background concentrations. Only cadmium, magnesium, selenium, and zinc were found to exceed both background levels and sample detection limits. No mobile ions were found to exceed background concentrations. The only volatile found in samples 2, 3, and 4 in excess of the detection limit is acetone. Eight semivolatiles on the TCL were found in the four samples. All of the BNAEs detected were PAHs. These organic compounds are believed to result from runoff from the airport.

Latty Avenue Properties

Soil samples obtained from HISS and Futura Coatings were analyzed for metals, mobile ions, VOCs, BNAEs, and RCRA-hazardous waste characteristics. Six boreholes were drilled at both HISS and Futura: three at random locations and three at biased locations at each property. Fourteen samples from HISS and 17 from Futura were analyzed. Sampling locations are shown in Figure 2-63.

Of the samples analyzed for VOCs, only 1 of the 12 samples from HISS and 4 of the 16 from Futura had VOCs at levels above detection limits. Toluene and fluorohydrocarbon, the only VOCs detected, were found at very low levels. Table 2-67 is a summary of the VOC results (BNI 1990e).

No TCL compounds were detected at levels exceeding the sample detection limits at either HISS or Futura when the initial BNAE scan was conducted. At HISS, an unidentified compound found was thought to represent breakdown products of substances present from

activities unrelated to MED/AEC activities. A benzene compound at 6,300 μg/kg and 2-propanol-1,3-dichlorophosphate at a concentration of 250,000 μg/kg were found at Futura (BNI 1990e).

Results of the metals analyses for HISS indicate that 16 metals are present in soil at concentrations exceeding background (Table 2-68). As was observed for SLAPS, cadmium, molybdenum, thallium, and selenium (when present at levels exceeding the detection limit) were found in all samples at concentrations exceeding the background levels. The distribution of metals with depth at HISS is similar to that observed at SLAPS; most of the metals appear to be confined to depths at or near the surface. Cadmium and magnesium were detected at levels exceeding background (see Figure 2-39) at depths greater [in excess of 1.2 m (4 ft)] than those to which radioactive contamination extended (BNI 1990e).

Results of the metals analyses for Futura indicate that 14 metals are present in soil at concentrations exceeding background levels. As was observed for SLAPS and HISS, cadmium, molybdenum, thallium, and selenium (when present at levels exceeding the detection limit) were found in all samples at concentrations exceeding background. In Boreholes 2 and 3, cobalt, magnesium, molybdenum, and copper were detected within the area of radioactive contamination [0 to 2.1 m (0 to 7 ft)] (see Figure 2-50). Only cobalt was found at greater depths [2.4 to 3.3 m (8 to 10 ft)]. In Borehole 1, radioactivity extends to 4.6 m (15 ft); no metals were detected below this depth. At the locations from which all random samples were collected, only magnesium and cadmium were detected within the area of radioactivity, and only magnesium was found underneath the known boundary of radioactivity [0.3 to 1.3 m (1 to 4 ft)]. Table 2-69 shows that 12 metals exceed the sample detection limit and background values (BNI 1990e).

Thirteen samples obtained from Futura were analyzed for the mobile ions sulfate, nitrate, and fluoride; results indicate that they are not present at Futura at concentrations exceeding those found in the background soils survey. At HISS, 11 samples were analyzed, and only 2 results are greater than those reported for background. Sulfate was found at a concentration of 824 ppm; the background concentration is 610 ppm. Nitrate was found in

one sample at 1,030 ppm; the background concentration is 868 ppm (BNI 1990e). Table 2-70 provides these results.

Analyses for RCRA-hazardous waste characteristics yielded negative results for reactivity, ignitability, corrosivity, and toxicity for the ten samples from Futura and the six from HISS (BNI 1990e).

Groundwater at the Latty Avenue Properties has been analyzed for metals and water quality indicator parameters. Metals were analyzed for five quarters during 1988 and 1989. Results are given in Tables 2-71 and 2-72, respectively. Monitoring well locations are shown in Figure 2-52. Specific conductance values show a good correlation with wells having high metal concentrations. TOC and TOX values show little change from location to location, indicating that there is no notable change in organic content. Groundwater was analyzed for priority pollutant organics in January 1989: 36 VOCs, 65 BNAEs, and 27 pesticides and PCBs. Only one organic BNAE compound [bis(2-ethylhexyl)phthalate] was found (in wells HISS-9 and B53W01D). Because the compound was detected in similar concentrations in laboratory blanks, the presence of this chemical is believed to be a result of laboratory contamination.

Chemical characterization was not conducted at the Latty Avenue vicinity properties because levels of metal and organic contamination are assumed to be comparable to those at the ball field area because the contamination mechanism was similar.

2.4.4 Summary of Site Conditions

The following conclusions are based on historical surveys of the St. Louis site, ongoing environmental monitoring, and site characterization activities:

St. Louis Downtown Site

- SLDS was used for processing uranium and compounds containing uranium from the mid-1940s to 1957 under MED/AEC contracts.

- Land surfaces at SLDS have been modified considerably since the 1940s through destruction of old buildings and construction of new ones.

- For remedial action considerations, the radioactive contaminants at SLDS are thorium-230, uranium-238, radium-226, and thorium-232. Any dose calculations will take into account radionuclides in the three naturally occurring decay chains.

- The maximum depth of contamination at SLDS is 12.8 m (42 ft).

- The volume of contaminated soil at SLDS is 220,200 m^3 (288,000 yd^3).

- Metals (i.e., antimony, arsenic, barium, boron, cadmium, chromium, cobalt, copper, lead, magnesium, manganese, mercury, molybdenum, selenium, silver, sodium, thallium, and zinc) exceed background concentrations in soil typically found throughout the United States (Table 2-8).

- There are a few small, isolated areas at SLDS where soil fails the hazardous waste criterion for EP toxicity-lead.

- Thirteen VOCs were detected in soil samples obtained at SLDS. Toluene was detected most frequently (20 of 23 boreholes), followed by chloroform and trichlorofluoromethane. In general, concentrations are low, with mean concentrations in the low parts per billion.

- Twenty-seven BNAE compounds (18 PAHs) were detected in soil samples obtained at SLDS. Pyrene was found most frequently, followed by fluoranthene, phenanthrene, and benzo(a)anthracene.

- For four quarters, groundwater monitoring was conducted at SLDS for pH, specific conductance, TOX, TOC, fluoride, nitrate, VOCs, BNAEs, and metals. Ten organic compounds were found, benzene most frequently. Indicator parameters show poor-quality groundwater. Sixteen metals were detected; those associated

with uranium ores (arsenic, barium, nickel, and selenium) were present in concentrations of 100 to 700 μg/L. Metals detected most frequently in soil were not found at elevated concentrations in groundwater.

- Data from the subsurface investigation indicate a basal bedrock unit overlain with two distinct unconsolidated units. A layer of rubble/fill material of variable thickness covers the surface. Groundwater flow direction is consistently eastward toward the Mississippi River.

- The limestone bedrock unit is shallow [5.8 m (19 ft)] under the western portion of the site, increasing in depth to 24.4 m (80 ft) with increasing proximity to the Mississippi River. Hydraulic conductivities for the bedrock range from 1.1×10^{-3} to 5.1×10^{-4} cm/s.

- The unconsolidated material above the bedrock consists of an upper hydrostratigraphic unit that is primarily fine materials and a lower hydrostratigraphic unit of coarser materials. An alluvial aquifer exists under semiconfined conditions.

- The upper hydrostratigraphic unit is made of unconsolidated clays and silts that are laterally continuous across the property. Hydraulic conductivities average 1×10^{-5} cm/s.

- The lower hydrostratigraphic unit is composed of unconsolidated silty sands and sands and is present only below the eastern portion of the property. Hydraulic conductivity is high in the lower unit.

St. Louis Airport Site

- SLAPS has been leveled since MED/AEC activities ceased, thus altering the original pattern of radioactive waste contamination.

- Uranium-238, radium-226, thorium-232, and thorium-230 were found at SLAPS as deep as 5.5 m (18 ft). The entire ground surface is contaminated in excess of DOE guidelines.

- The volume of contaminated soil at SLAPS is 191,000 m^3 (250,000 yd^3).

- Environmental monitoring results for SLAPS indicate that radon levels and measured concentrations of radionuclides in surface water have remained low and relatively constant since 1984, when monitoring began. External gamma radiation exposure rates are measured at nine locations. For the last four years, only one location has shown readings greater than 130 mR/yr above background (background readings in the St. Louis area average approximately 100 mR/yr). Radon levels at only one location have shown a reading greater than 3.0 pCi/L, the DOE post-remedial action guideline for radon, for the last six years, although Missouri state regulations for radon (1 pCi/L) have been exceeded at several locations. Surface water concentrations of total uranium, radium-226, and thorium-230 have been less than 5.0 pCi/L for the last five years. Groundwater has shown relatively stable levels of radium-226 and thorium-230; however, uranium levels have fluctuated and, in monitoring wells A, B, D, E, F, M11-21, and M11-9, exceed the proposed Uranium Mill Tailings Radiation Control Act (40 CFR 192) guideline of 30 pCi/L for concentrations of uranium in groundwater.

- Chemical characterization of soil at SLAPS indicates very low concentrations of VOCs. No samples failed the RCRA-hazardous waste characteristics tests.

- At SLAPS 15 metals are present in soil at concentrations exceeding background levels. Most of the metals appear to be confined to near-surface depths; only magnesium, cadmium, and cobalt were detected beneath the maximum depths of radioactive contamination.

- Groundwater at SLAPS was analyzed for pH, specific conductivity, TOX, TOC, and metals; results show the groundwater to be of poor quality. The same 16 metals found in soil samples from the property were also detected in groundwater. Five organics were detected at very low levels.

- Data from the subsurface investigation indicate three major geologic units: a basal limestone unit, a siltstone unit, and an unconsolidated unit. Monitoring well data confirm that the entire stratigraphic sequence is saturated from an average depth of 3 m (10 ft) below ground surface. Locally, a substantial vertical hydraulic gradient potential exists in the upward direction at SLAPS. Regional flow direction is northwest to the Missouri River.

- The basal limestone unit is encountered at 21.3 to 27.4 m (70 to 90 ft). Hydraulic conductivities average 1 x 10^{-6} cm/s.

- The siltstone unit overlying the basal limestone unit is encountered at a shallow depth [15.4 m (50 ft)] only under the southeastern portion of the property.

- The unconsolidated material overlying the siltstone unit consists primarily of clays, silty clays, and peat, and it is continuous over the entire property. Abundant zones of decomposed organic material are included in the unit and encountered throughout the central portion of the property. Hydraulic conductivity for the overburden material ranges from 10^{-6} to 10^{-8} cm/s.

Hazelwood Interim Storage Site and Futura Coatings

- The HISS and Futura radiological characterization found that a majority of the ground surface is contaminated in excess of DOE guidelines. Radioactive contamination was found to a depth of 2 m (6 ft) at HISS and 4.6 m (15 ft) at Futura.

- The volume of contaminated soil at HISS is 53,520 m^3 (70,000 yd^3), including the stockpiled material. The volume of contaminated soil at Futura is 26,000 m^3 (34,000 yd^3).

- Environmental monitoring results for HISS indicate that external gamma radiation exposure rates have decreased sharply since 1984 at most monitoring locations; overall radon concentrations have remained basically stable since 1984; and concentrations of uranium, radium-226, and thorium-230 in surface water have been stable since 1985. Concentrations of most radionuclides in groundwater have changed little since 1985; however, uranium concentrations in Well 6 have shown increases in the last four years. Since 1987, annual average external gamma radiation exposure rates have remained less than 85 mR/yr, after background has been subtracted, except at one sampling location. All annual averages of radon-222 have remained less than 2.0 pCi/L since 1985. Annual average measurements for surface water show total uranium concentrations to be less than 5.0 pCi/L since 1985; radium-226 and thorium-230 have shown concentrations of less than 0.4 pCi/L since 1984.

- Chemical characterization at HISS and Futura indicates concentrations of metals exceeding background (as also shown at SLDS and SLAPS). The distribution of metals within the regions of radioactive contamination at HISS was similar to that at SLAPS; both properties show contamination at shallow depths, but metals exceeding background concentrations were found at shallower depths at Futura than at HISS.

- Analyses for VOCs and BNAEs at HISS and Futura resulted in the identification of only two VOCs (toluene and trichlorofluoromethane) and no BNAEs that are on the TCL (see Appendix E).

- No samples at HISS or Futura exhibited any RCRA-hazardous waste characteristics.

- Groundwater at the Latty Avenue Properties was analyzed for pH, specific conductance, TOX, TOC, and metals; results are similar to those found for SLAPS.

- At HISS groundwater levels in the overburden range in depth from 1.5 to 4.9 m (5 to 16 ft). The consistent groundwater flow pattern is radial outward from the downslope toe of the main pile. Seasonal fluctuations in the water levels reflect insignificant changes in gradient value and flow directions.

Vicinity Properties

- All vicinity properties have been characterized for radioactive contamination only, with the exception of the ball field area and surface water from Coldwater Creek. Thorium-230 was found to be the primary contaminant on all vicinity properties.

- The ball field chemical characterization found two VOCs--toluene and 1,1,1-trichloroethene--in soil. Nine metals were found in excess of background concentrations. No samples exhibit any RCRA-hazardous waste characteristics. Dieldrin was found in low concentrations when PCB/pesticide analysis was conducted.

- Samples collected for chemical analysis from Coldwater Creek show four metals at concentrations exceeding background levels. Acetone exceeds the detection limit in three samples, and eight semivolatiles were detected in the four samples.

- Subsurface data are limited to the unconsolidated overburden materials, which are clays and silts. Abundant organic material of variable thicknesses is included in the overburden.

2.5 RESPONSE ACTIONS CONDUCTED TO DATE

In 1984 DOE directed ORNL to conduct a survey of the Latty Avenue vicinity properties. ORNL discovered that contamination had been redistributed since the 1981 and 1983 surveys conducted by ORAU and ORNL, respectively. The redistribution was probably a result of flooding, surface runoff, and utility company activities. The major contaminant found is thorium-230; radium-226 and uranium-238 are present in lesser amounts.

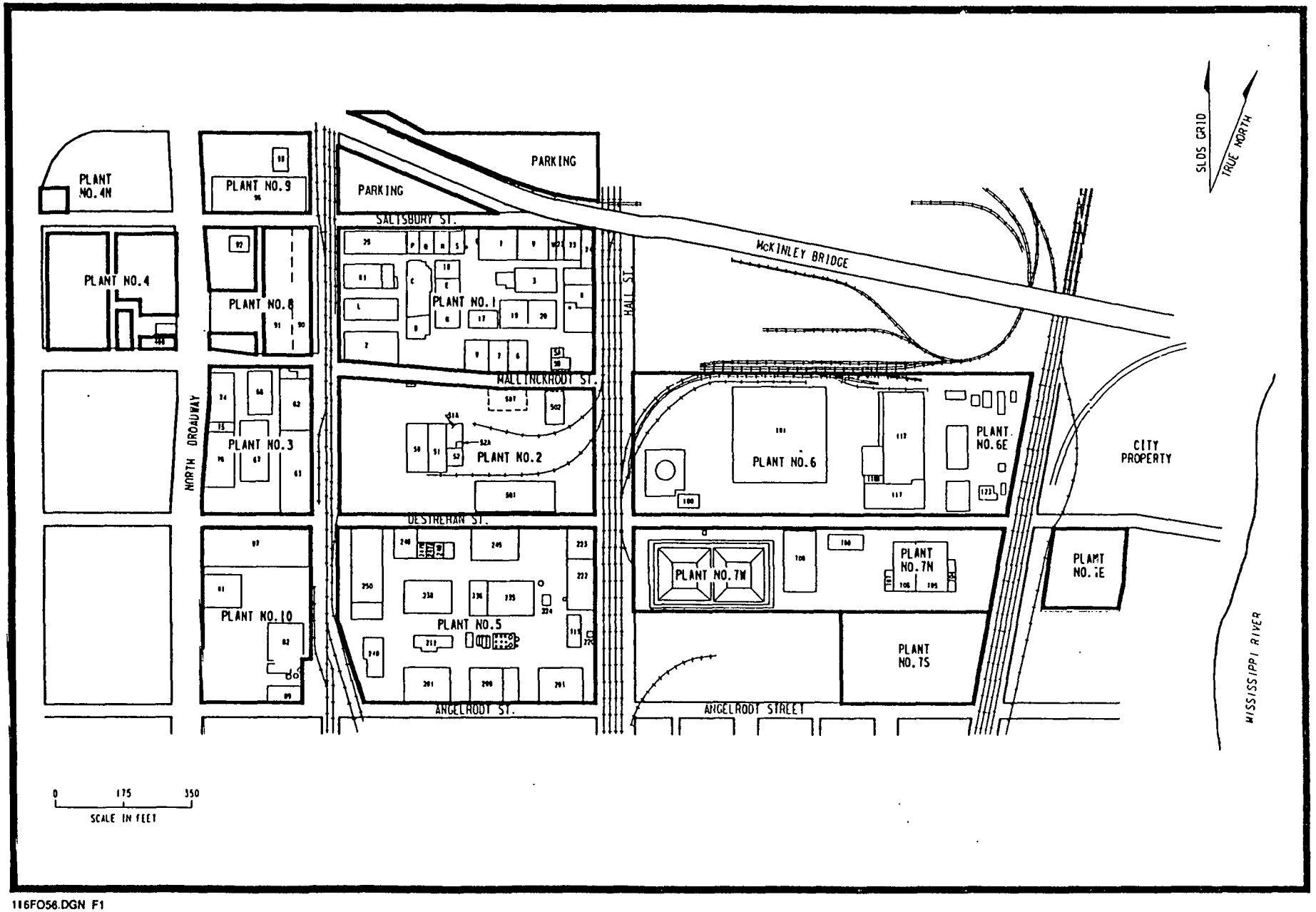
In 1984 DOE directed BNI to perform remedial action on the contaminated areas within the temporary slope and construction line along Latty Avenue (BNI 1985e). The temporary slope and construction line included all areas that could have been disturbed during a drainage improvement project conducted by the cities of Hazelwood and Berkeley. During the remedial action, contamination exceeding guidelines was found to extend beyond the temporary slope and construction line. Approximately 10,700 m^3 (14,000 yd^3) of contaminated soil from this work was moved to interim storage at HISS.

In 1985 erosion on the western side of SLAPS along Coldwater Creek necessitated emergency maintenance. Sloughing and seepage were causing erosion of contaminated fill material into the creek. During a 7-week period beginning in March, a retaining wall was installed along the bank.

In 1986 DOE directed BNI to provide radiological support to Berkeley and Hazelwood during a road improvement project. Radium-226 and thorium-230 contamination in excess of DOE remedial action guidelines was found at depths ranging from 0.6 to 2.4 m (2 to 8 ft) along and under Latty Avenue. Materials contaminated in excess of remedial action guidelines were removed and placed in storage at HISS. Approximately 3,517 m^3 (4,600 yd^3) of material was placed in a storage pile developed specifically to accommodate it and covered with a low-permeability membrane. In addition to gamma scanning the soil that was not placed in storage at HISS, gross alpha counting was used as a screening technique. Soil samples were scanned for alpha-emitting radionuclides (such as thorium-230) that exceed DOE guidelines. Soils that did not exhibit contamination in excess of DOE guidelines were used as fill material on the railroad property between Futura Coatings and Coldwater Creek

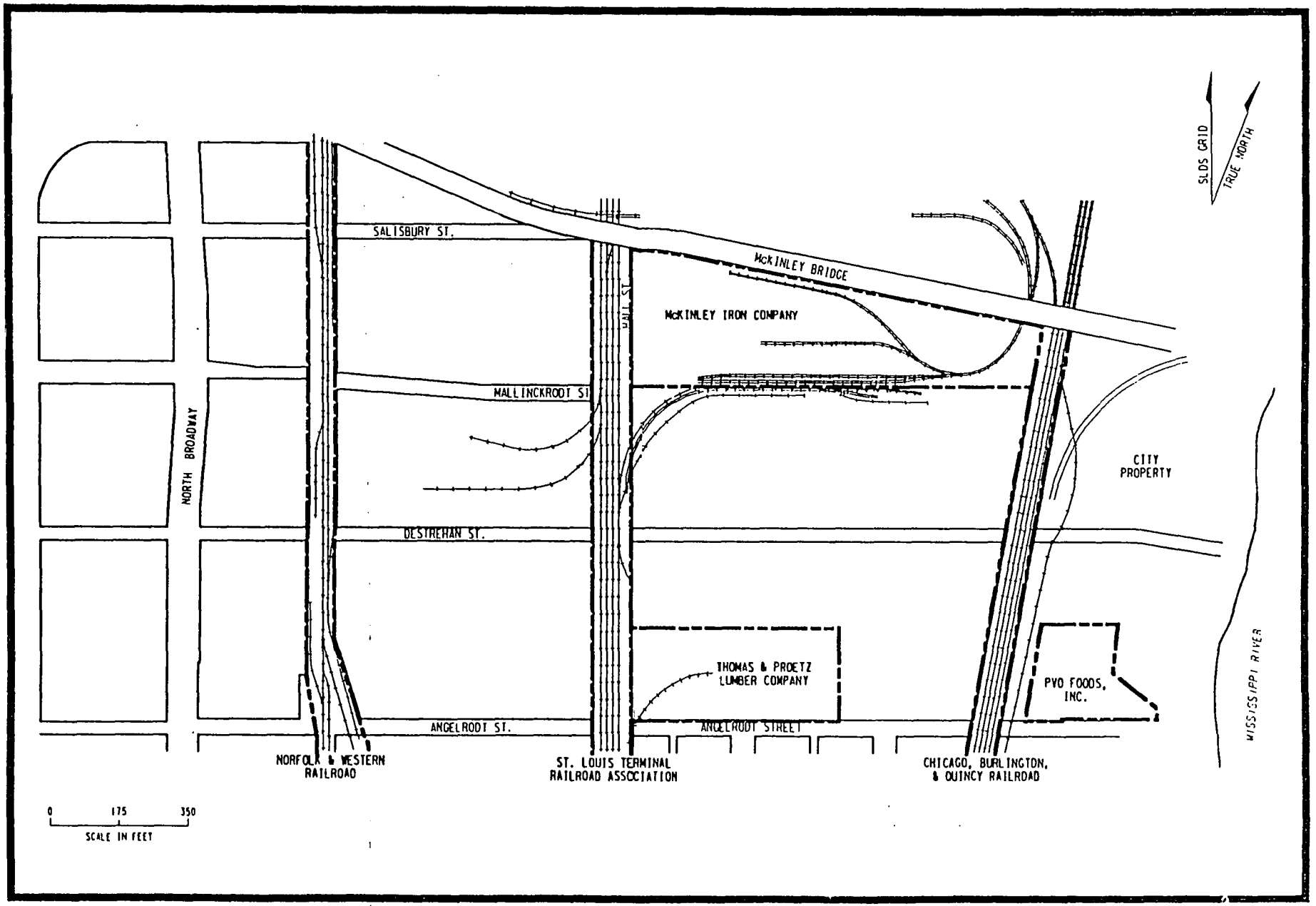
and along the entire length of Latty Avenue. Contaminated material at Latty Avenue was loaded directly into trucks, transported to HISS, and placed in interim storage. Both piles are covered with a low-permeability membrane called Futura Ply II.

FIGURES FOR SECTION 2.0



116FO56.DGN F1

FIGURE 2-1 PLAN VIEW OF SLDS



116F056.DGN F2

FIGURE 2-2 PLAN VIEW OF THE SLDS VICINITY PROPERTIES

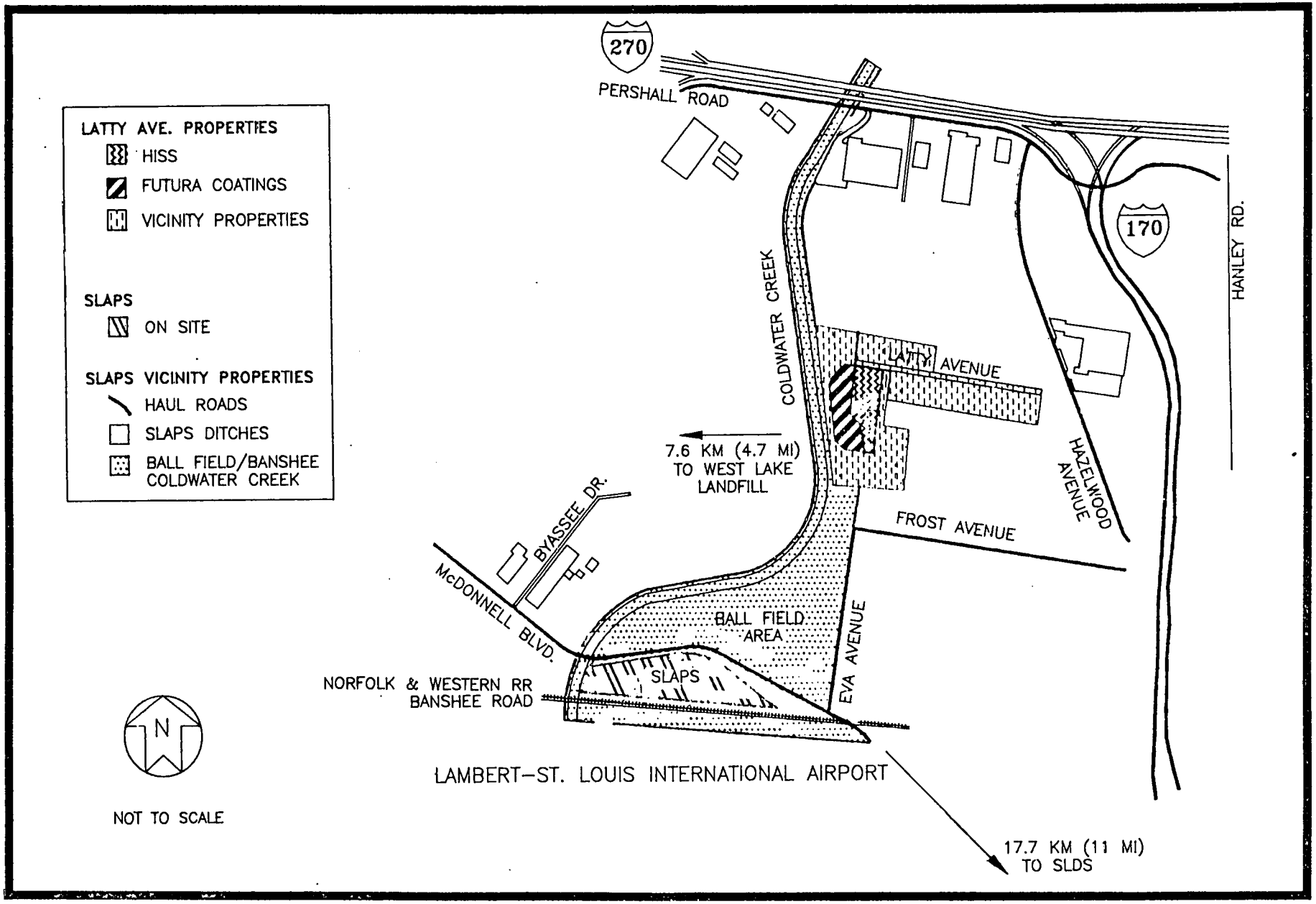


FIGURE 2-3 LOCATIONS OF SLAPS, LATTY AVENUE PROPERTIES, AND VICINITY PROPERTIES

B1:SLAPGEN1:V1

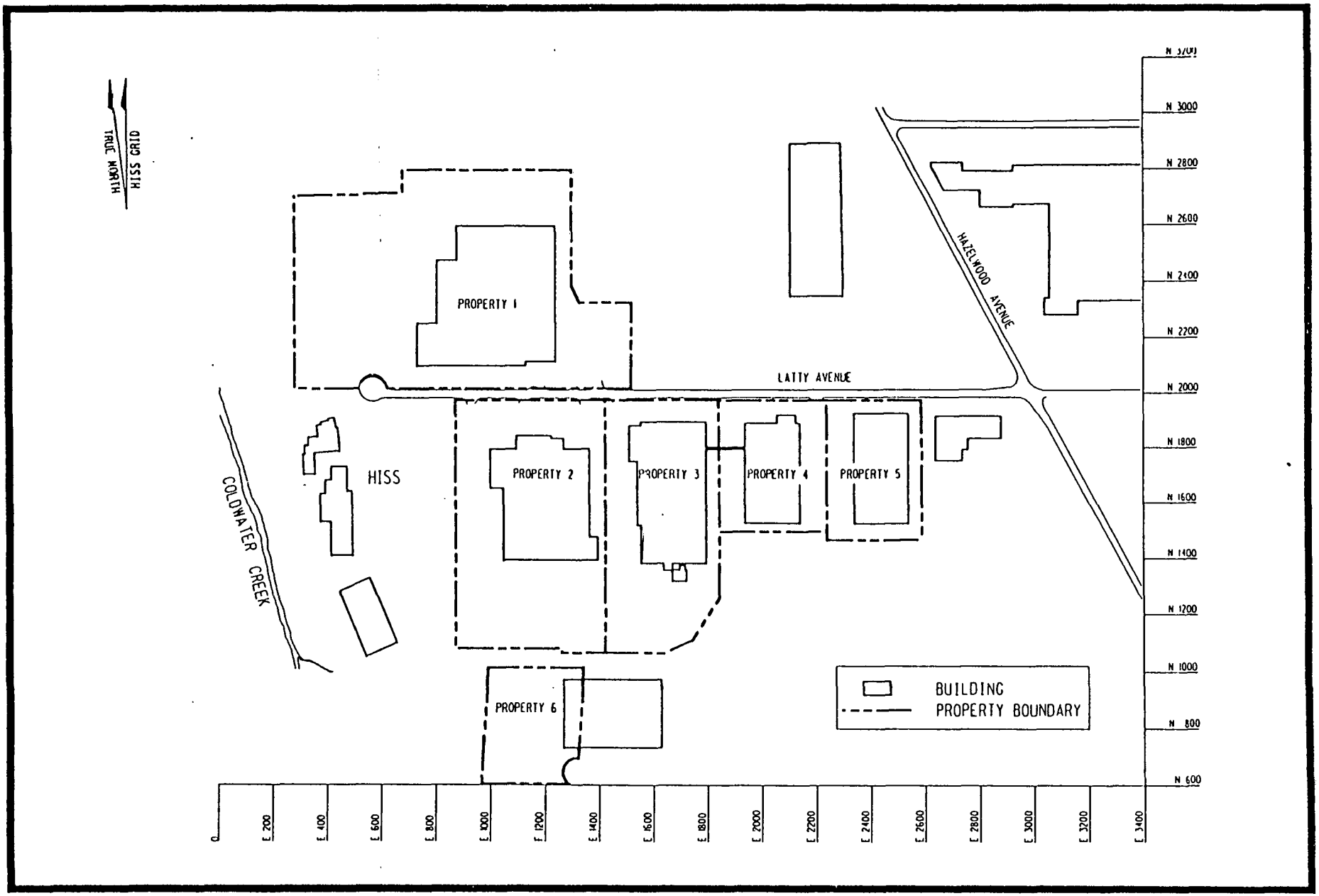


FIGURE 2-4 LOCATIONS OF LATTY AVENUE AND VICINITY PROPERTIES

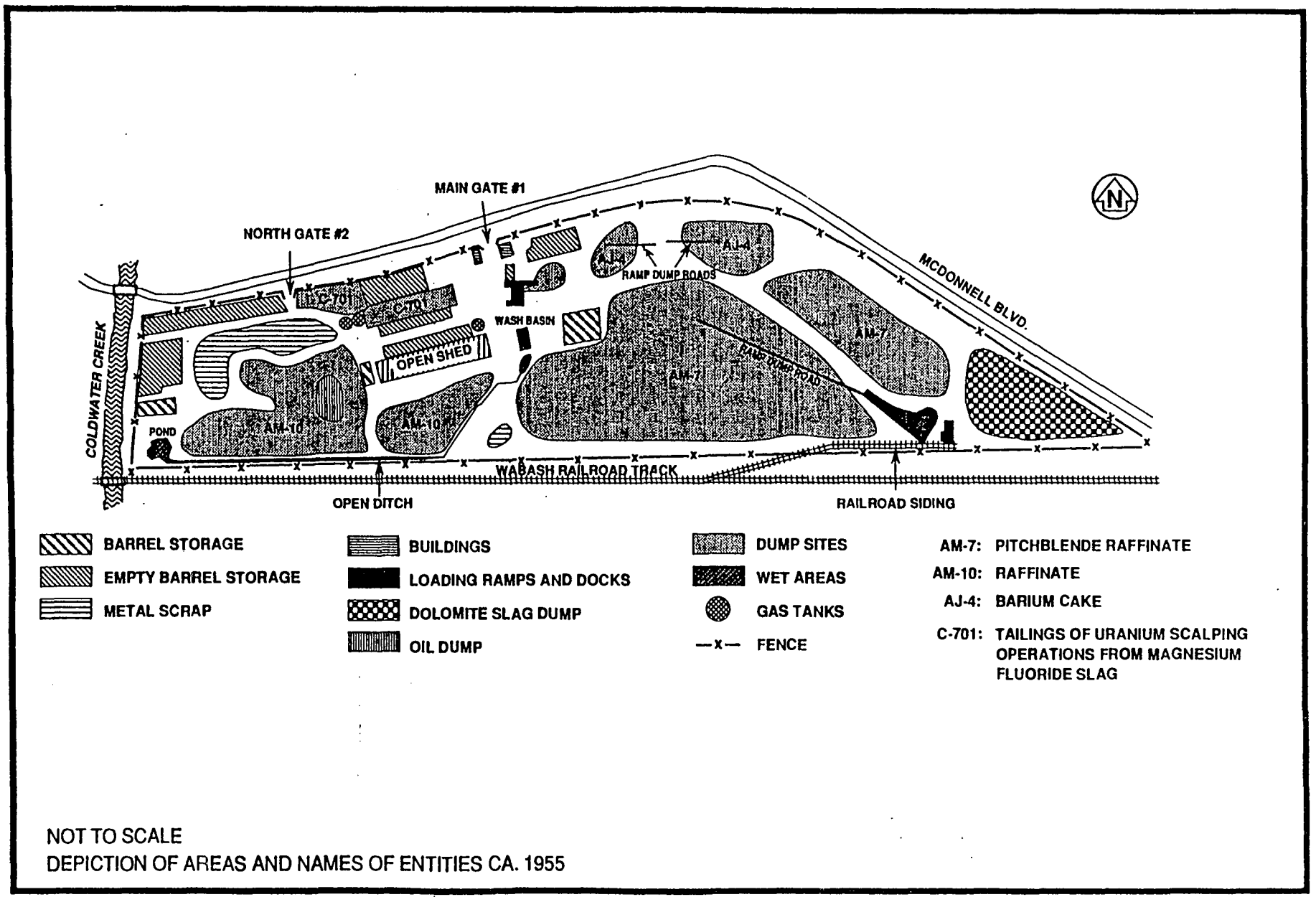


FIGURE 2-5 FORMER AREAS OF USE AND WASTE STORAGE AT SLAPS

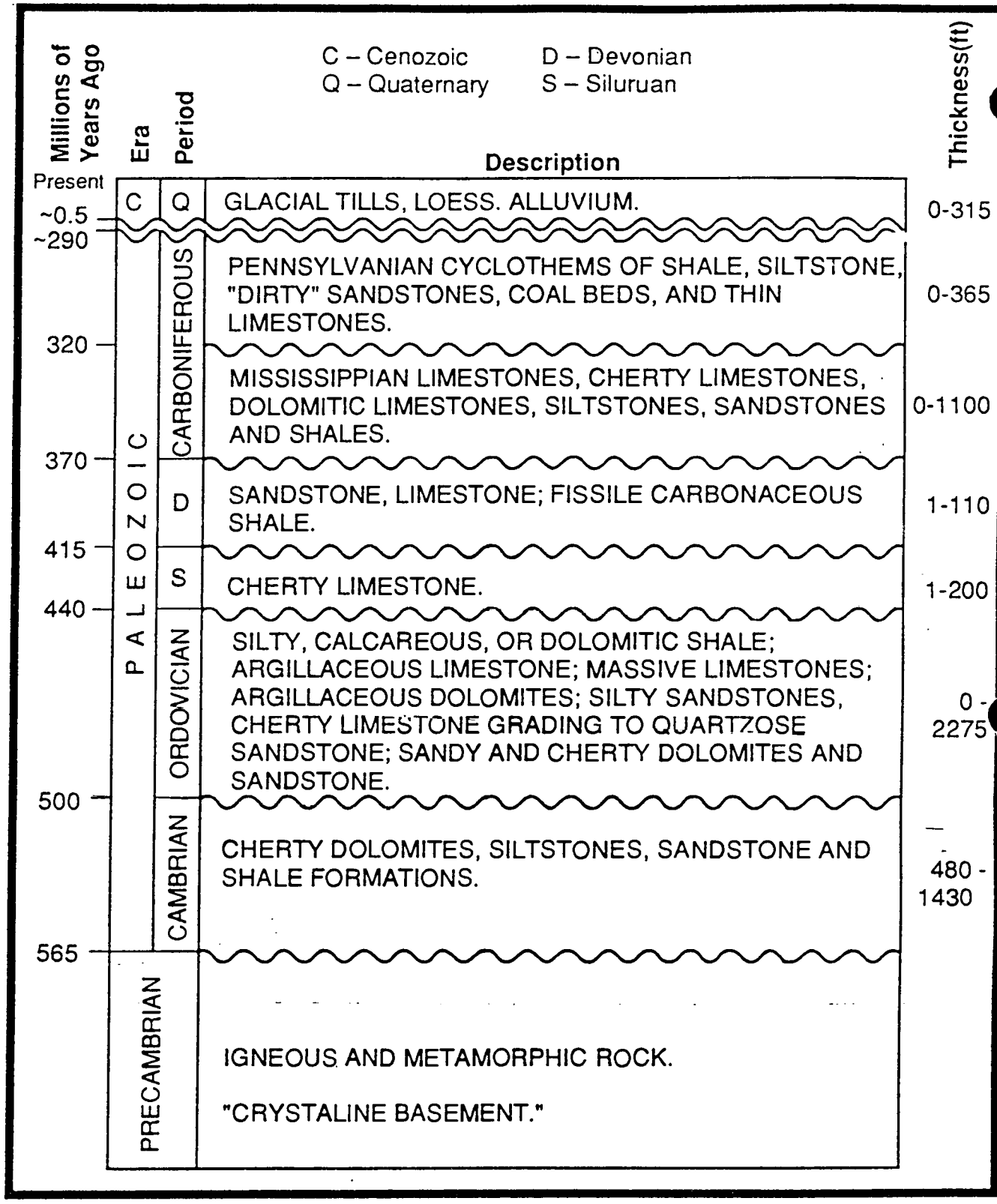


FIGURE 2-6 GENERALIZED STRATIGRAPHIC COLUMN FOR THE ST. LOUIS REGION

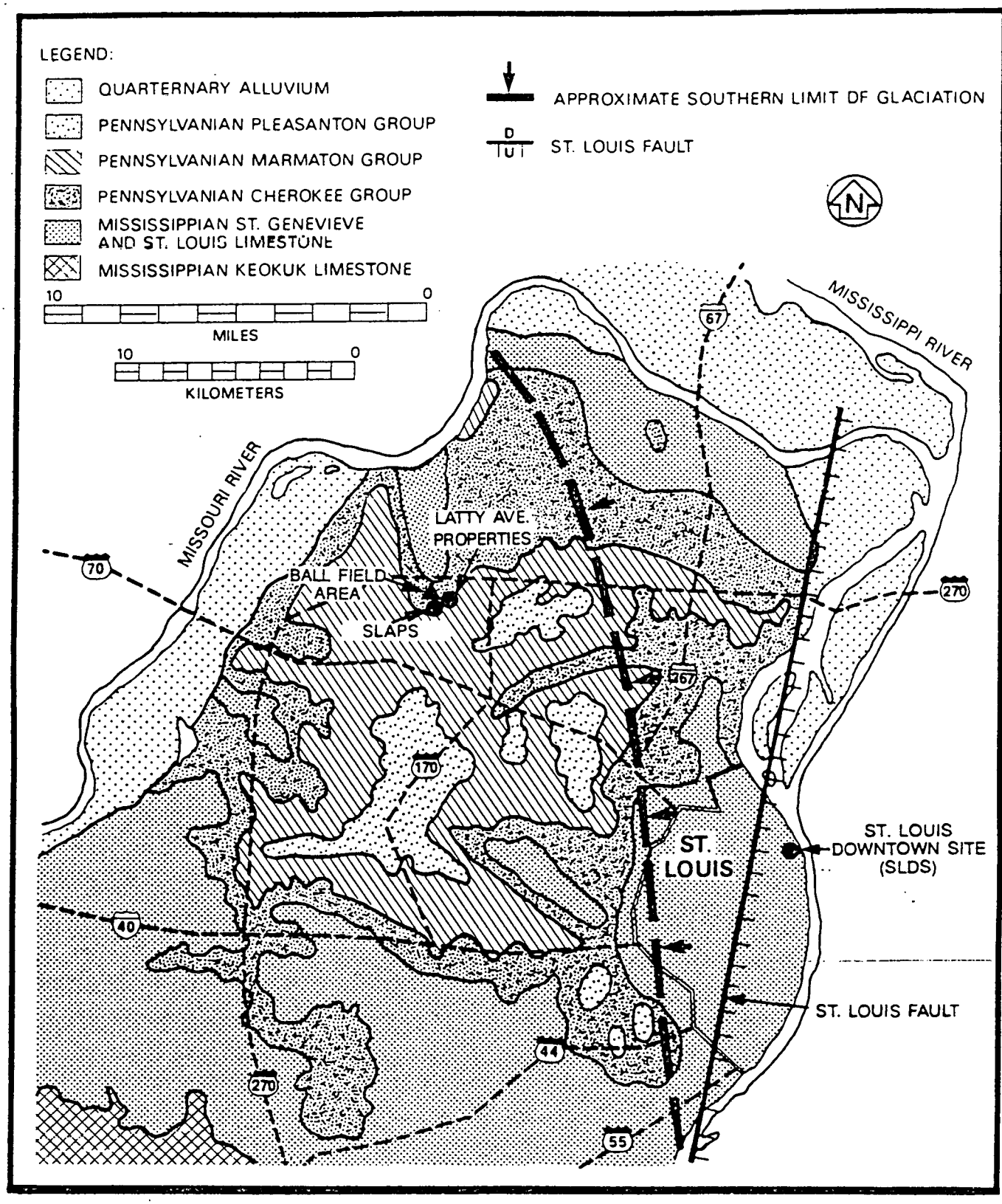


FIGURE 2-7 GENERALIZED BEDROCK GEOLOGIC MAP OF THE ST. LOUIS AREA

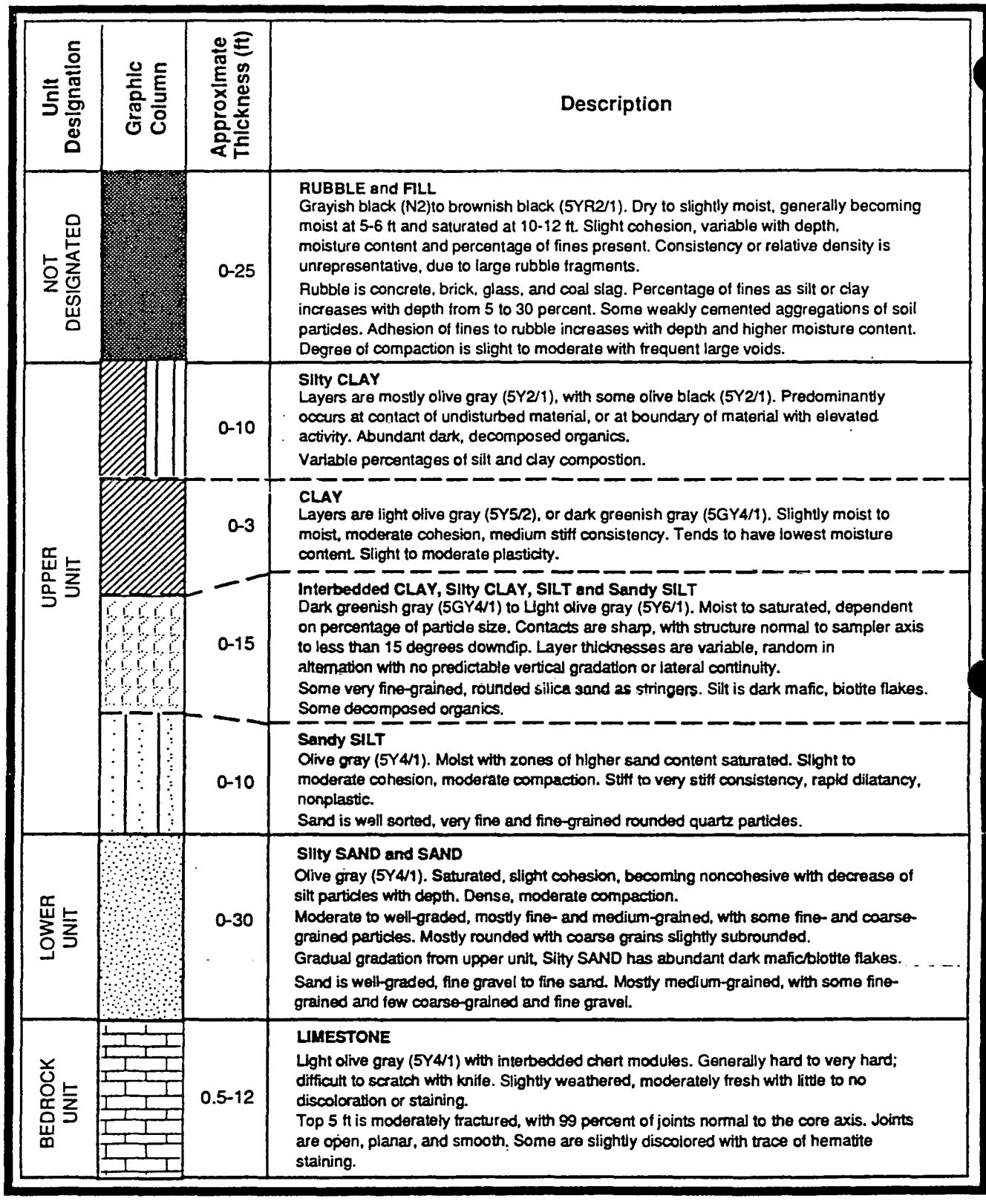


FIGURE 2-8 GENERALIZED STRATIGRAPHIC COLUMN FOR SLDS

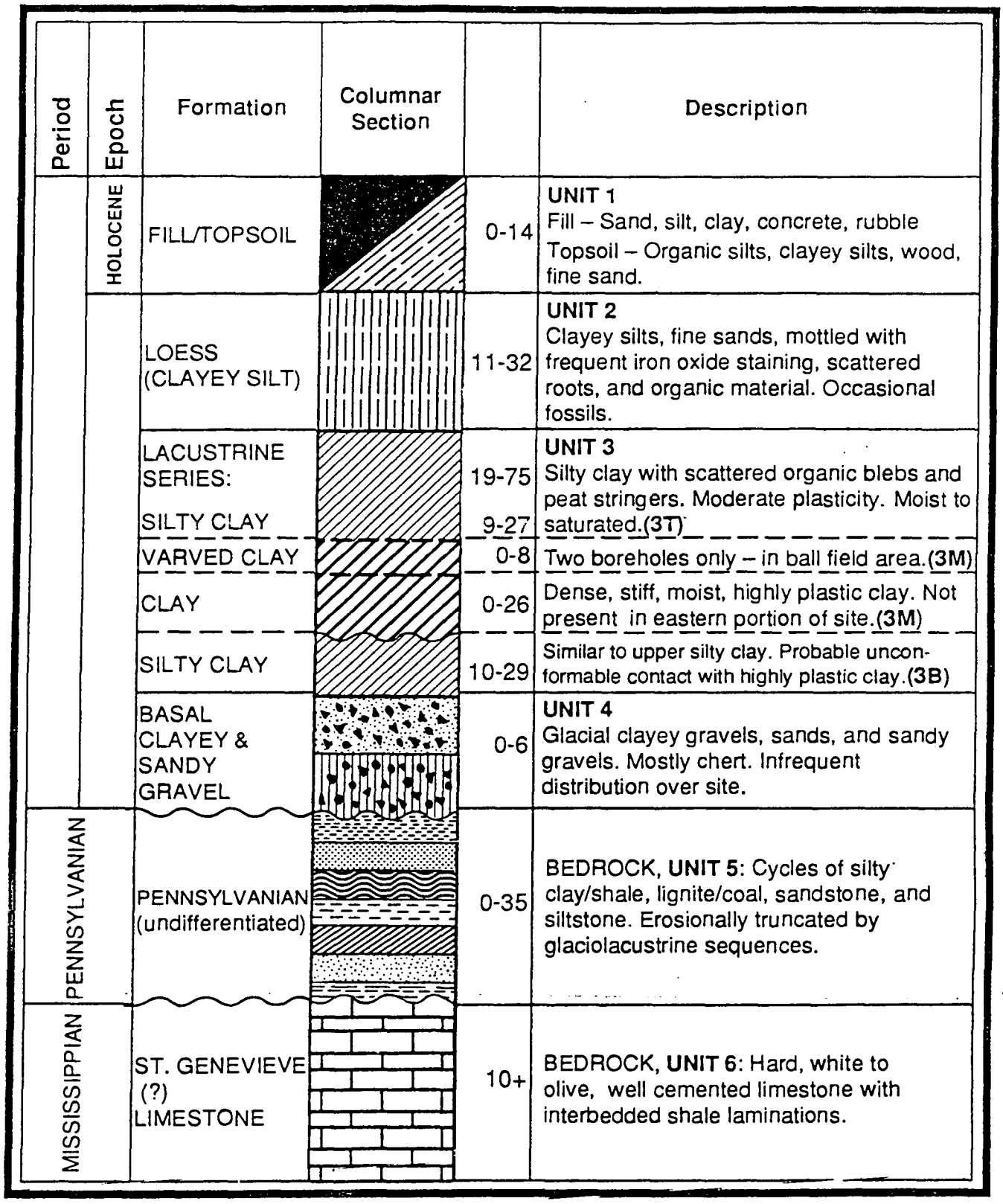
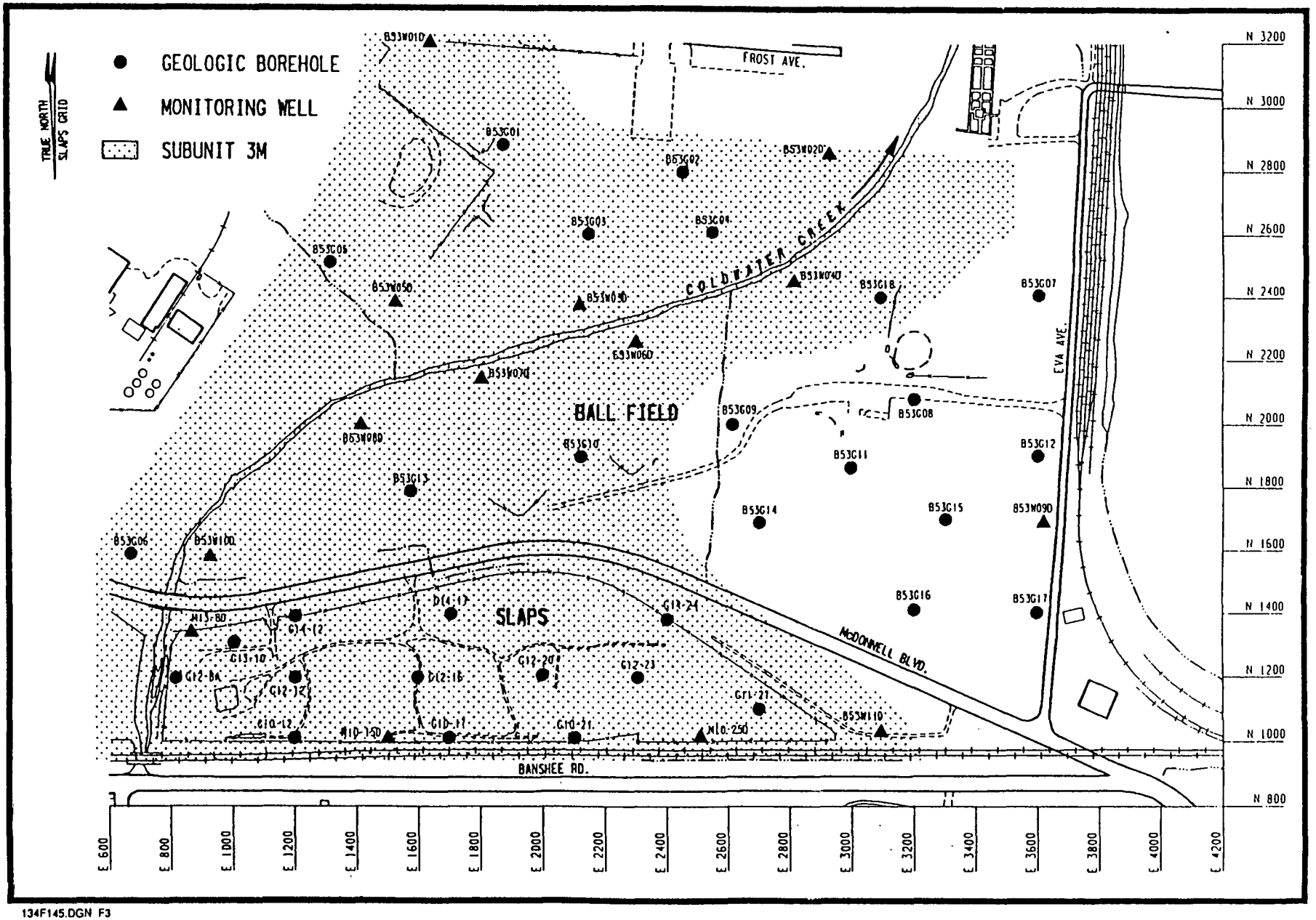


FIGURE 2-9 GENERALIZED STRATIGRAPHIC COLUMN FOR SLAPS AND THE BALL FIELD AREA



134F145.DGN F3

FIGURE 2-10 APPROXIMATE EXTENT OF SUBUNIT 3M IN THE SLAPS/BALL FIELD AREA

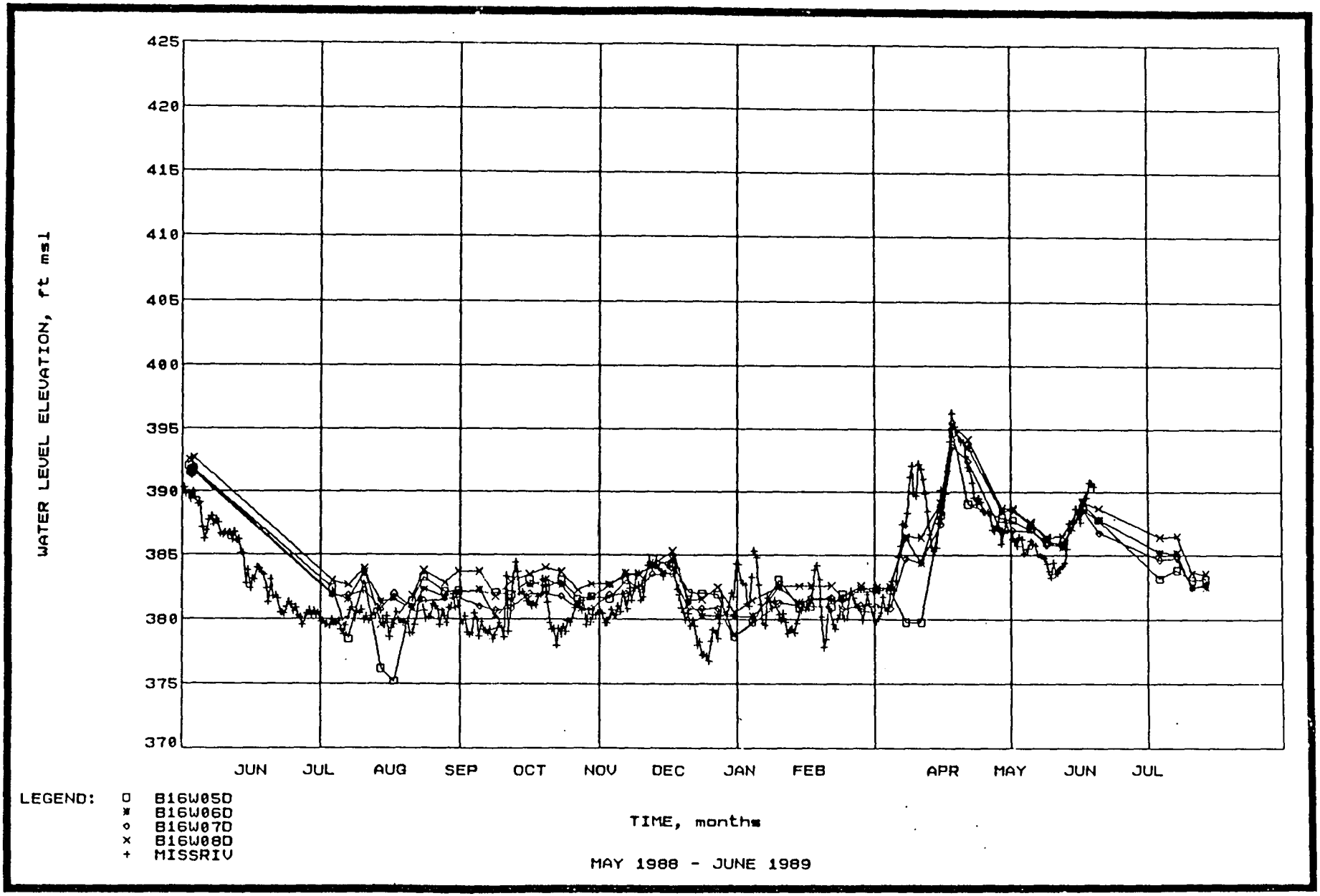
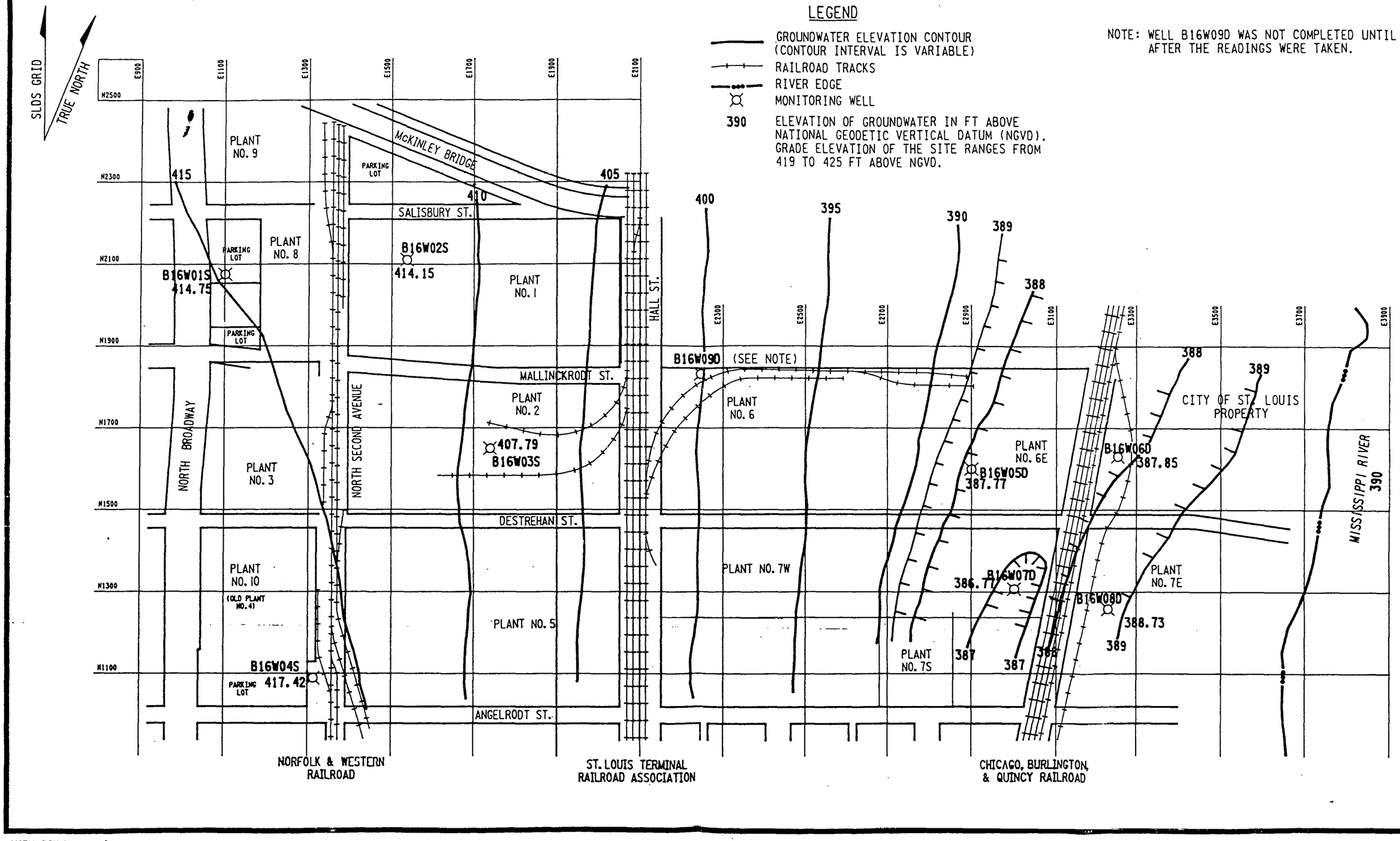


FIGURE 2-11 HYDROGRAPHS OF MONITORING WELLS OF UNCONSOLIDATED DEPOSITS AT SLDS



116F021.DGN 3

FIGURE 2-12 POTENTIOMETRIC SURFACE FOR SLDS, JUNE 9, 1989

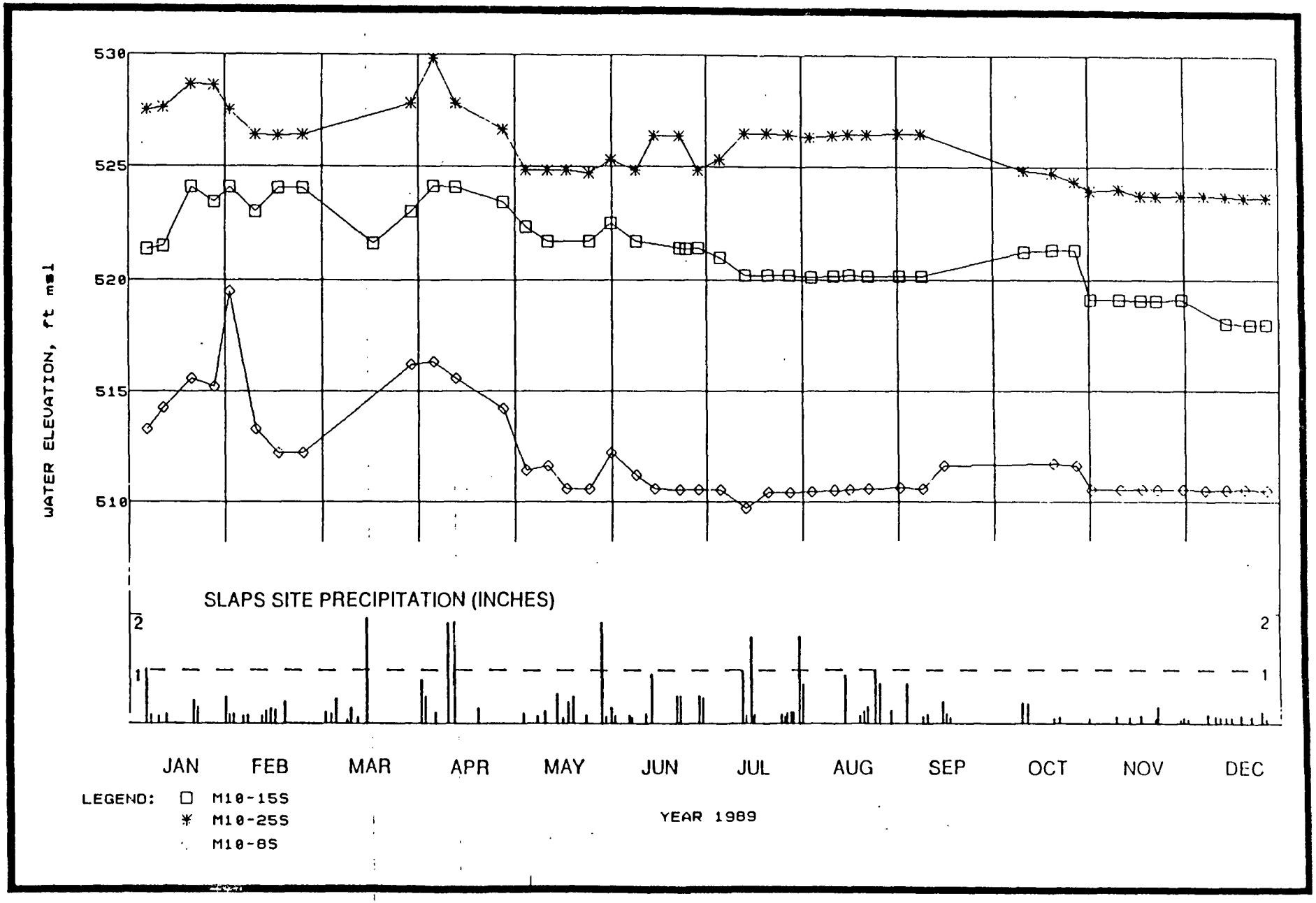


FIGURE 2-13 HYDROGRAPHS OF UPPER GROUNDWATER SYSTEM WELLS M10-15S, M10-25S, AND M10-8S

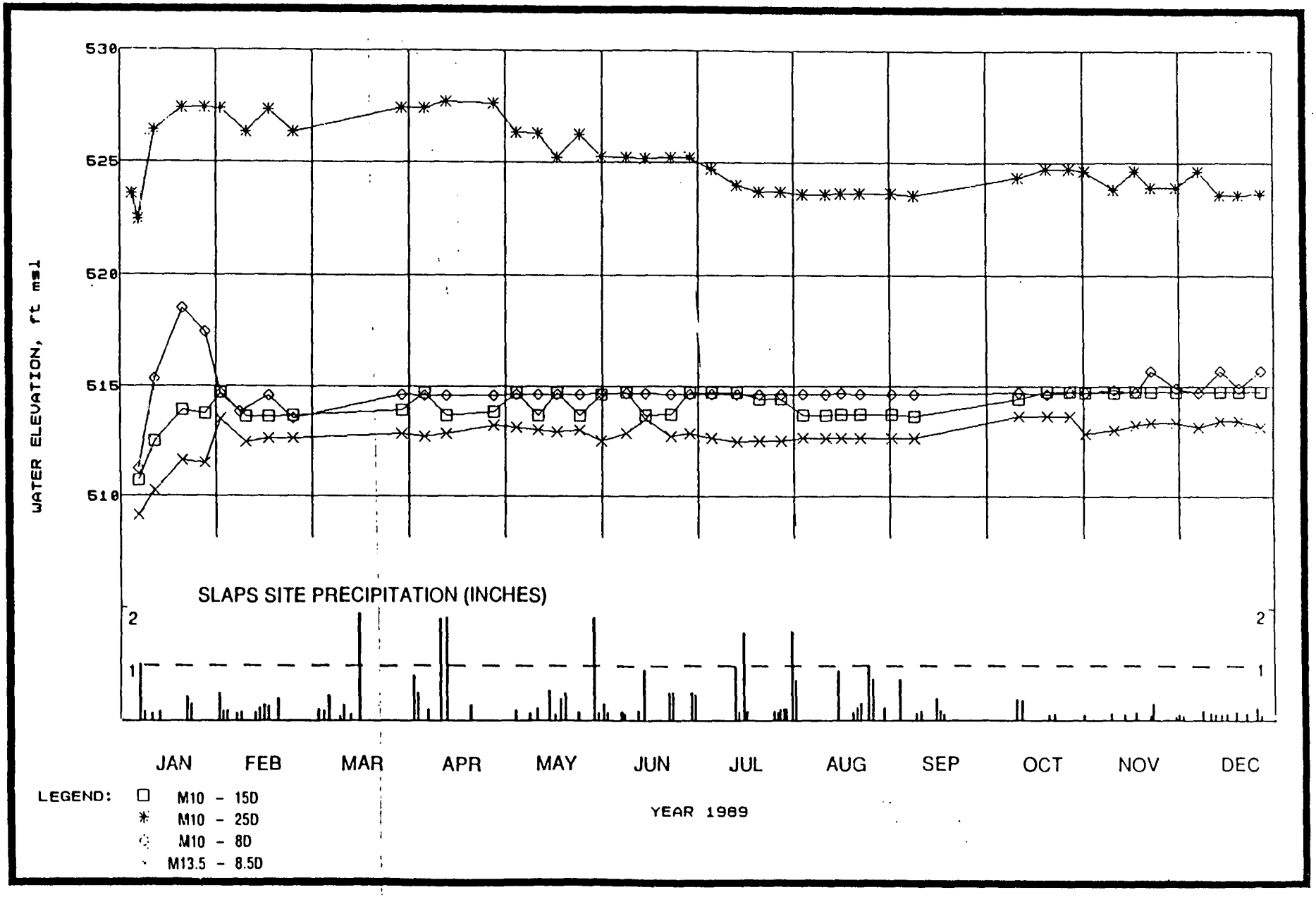


FIGURE 2-14 HYDROGRAPHS OF LOWER GROUNDWATER SYSTEM WELLS M10-15D, M10-25D, M10-8D, AND M13.5-8.5D

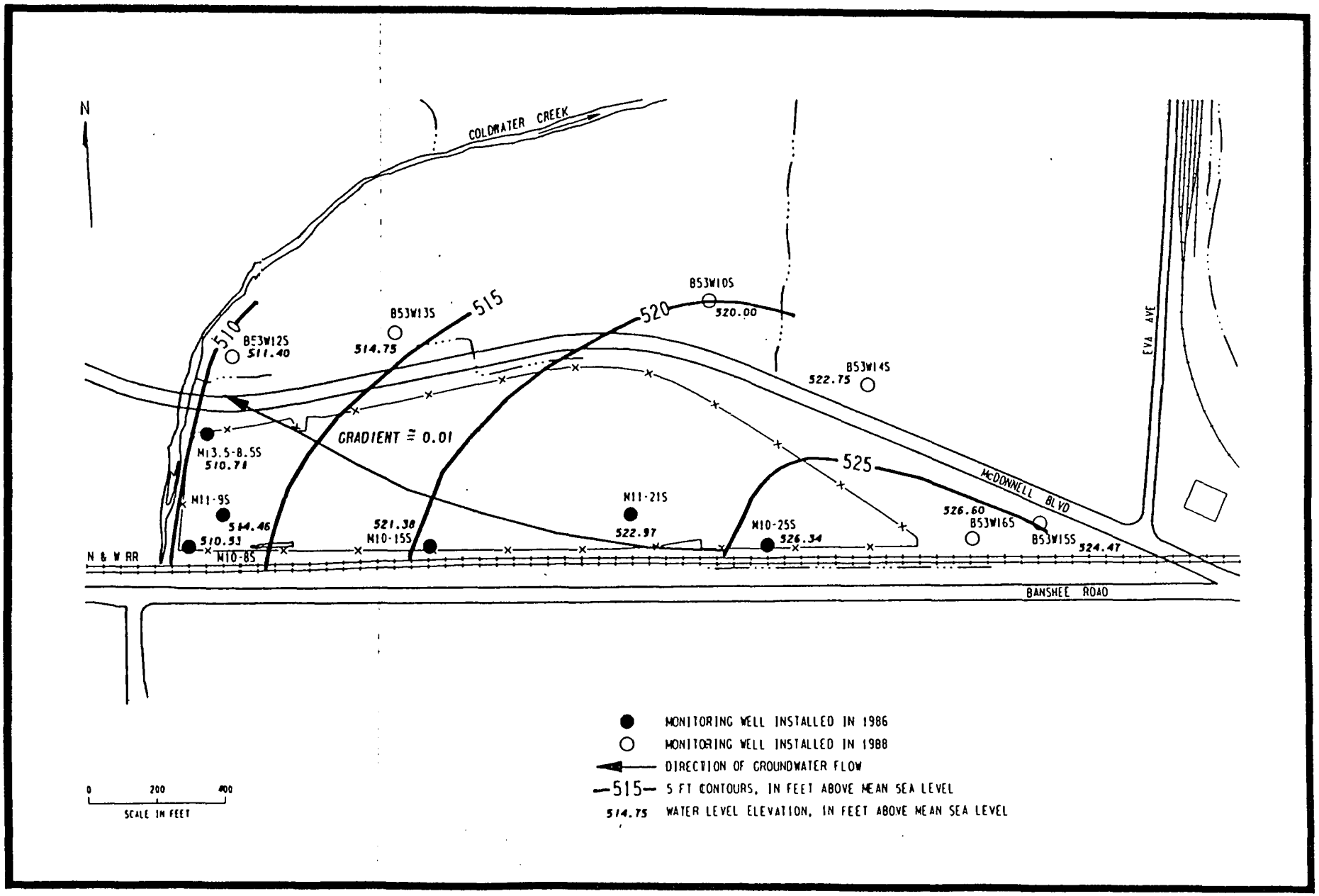


FIGURE 2-15 UPPER GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE FOR SLAPS AND THE BALL FIELD AREA, JUNE 23, 1989

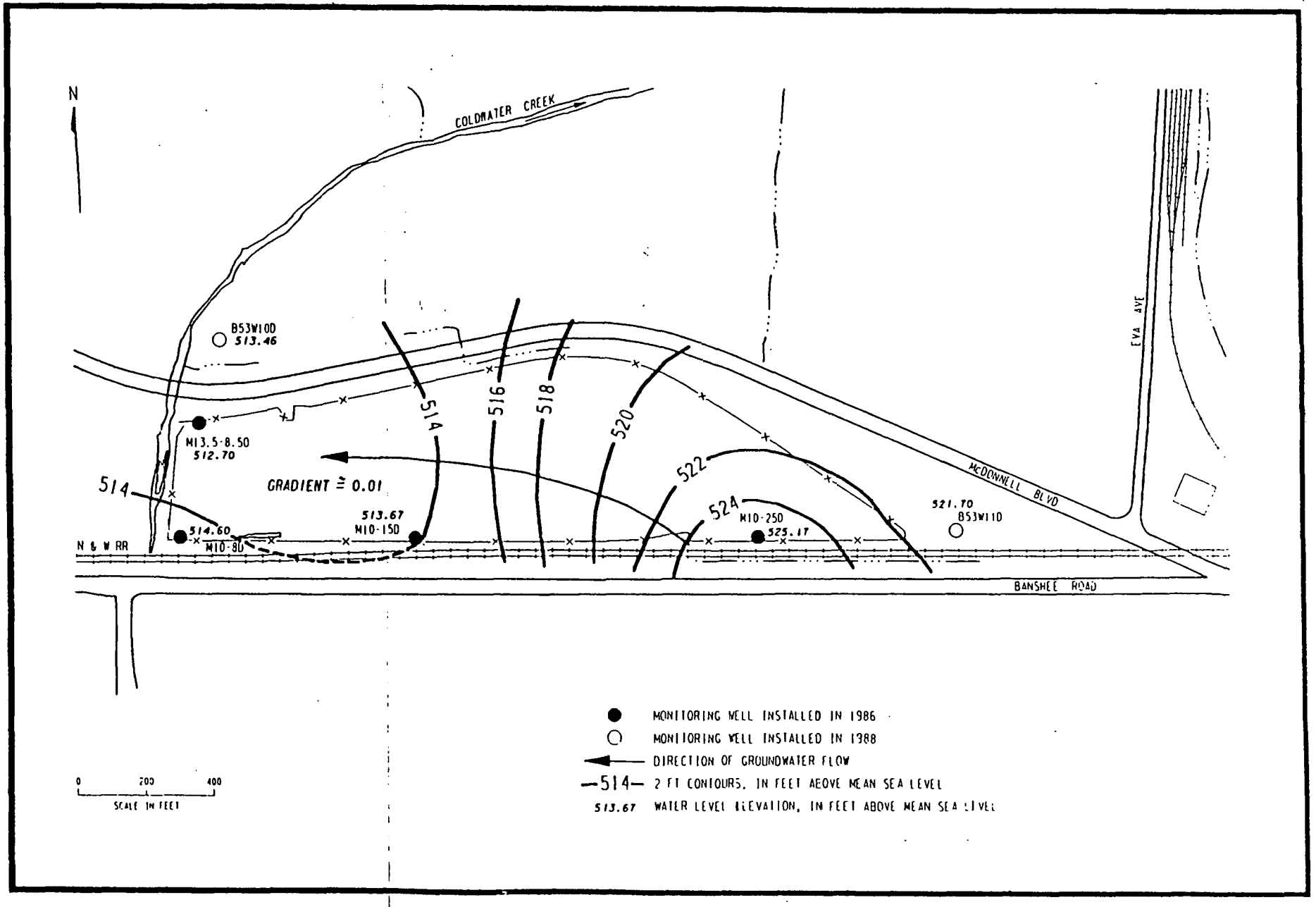


FIGURE 2-16 LOWER GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE FOR SLAPS AND THE E[illegible]L FIELD AREA, JUNE 23, 1989

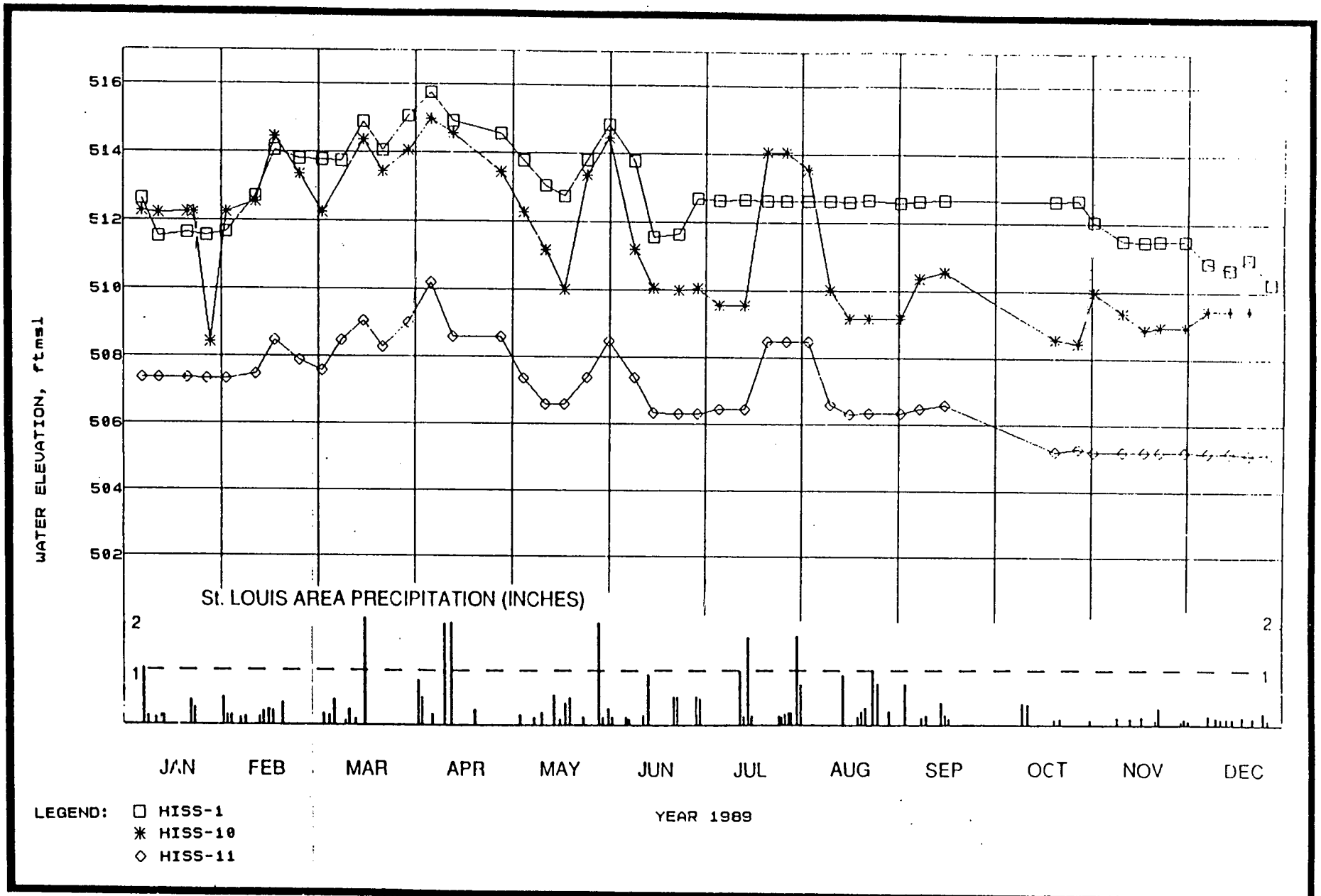
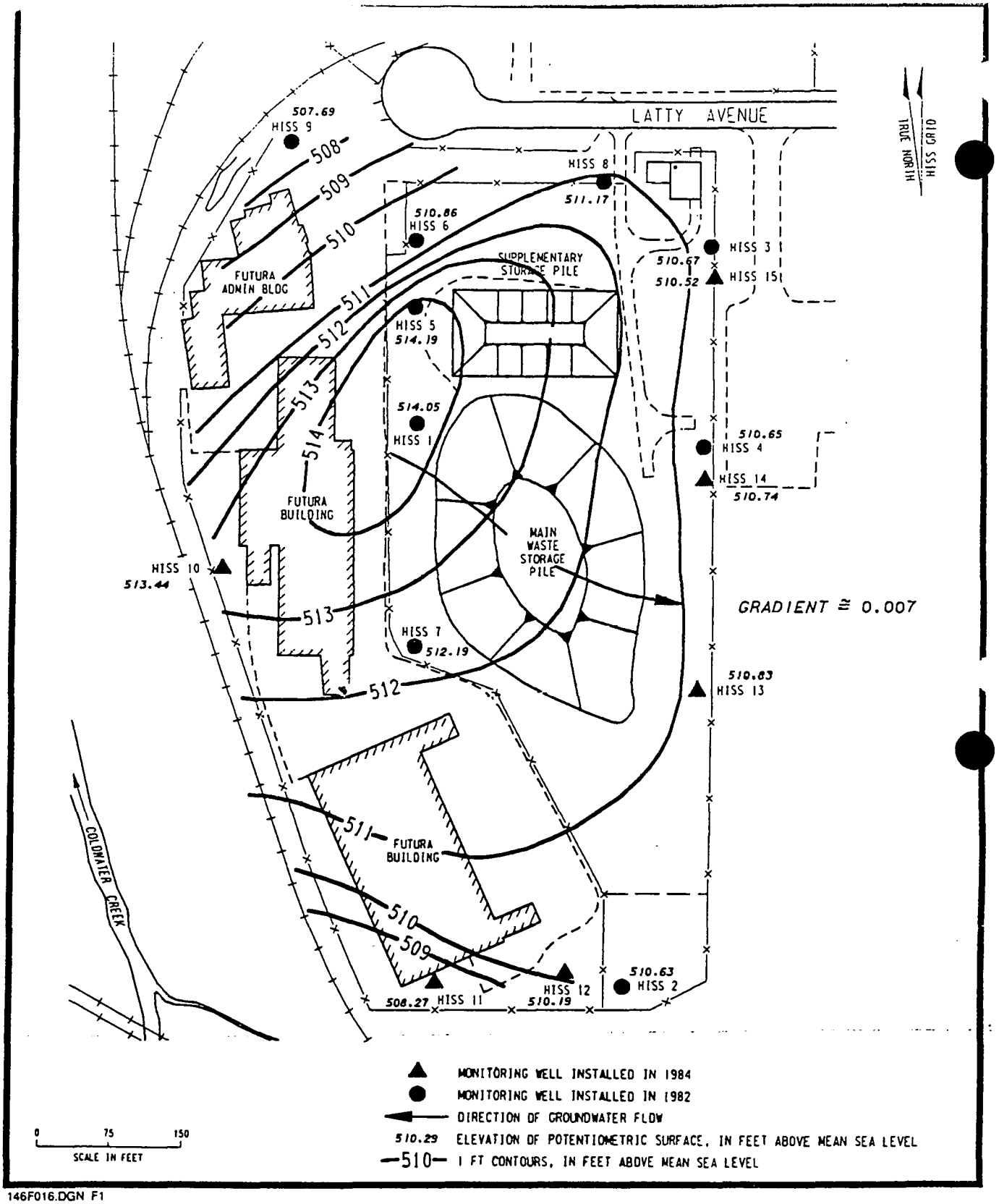


FIGURE 2-17 HYDROGRAPHS OF WELLS HISS-1, HISS-10, AND HISS 11



146F016.DGN F1

FIGURE 2-18 POTENTIOMETRIC SURFACE FOR HISS/FUTURA, MARCH 23, 1989

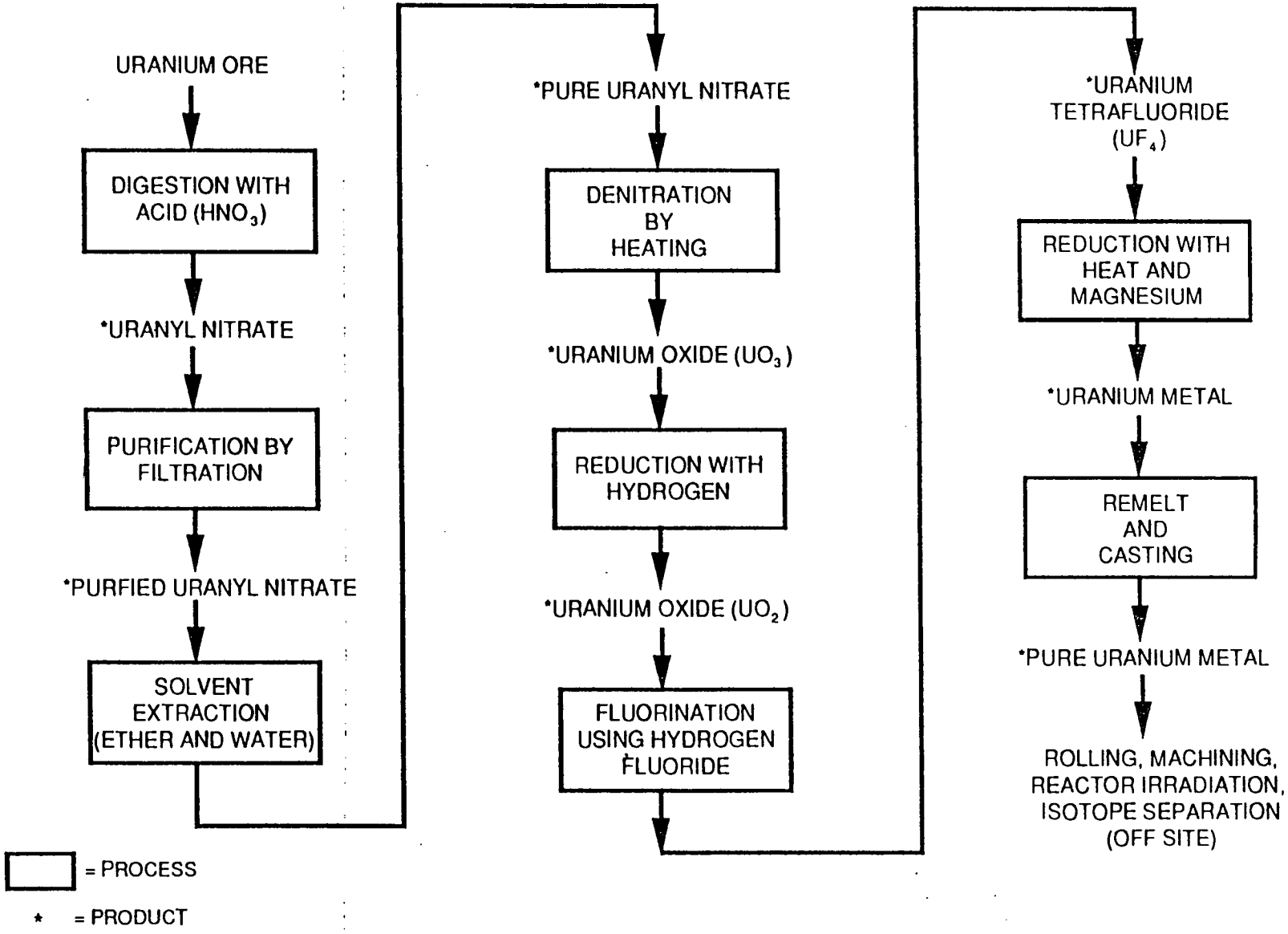
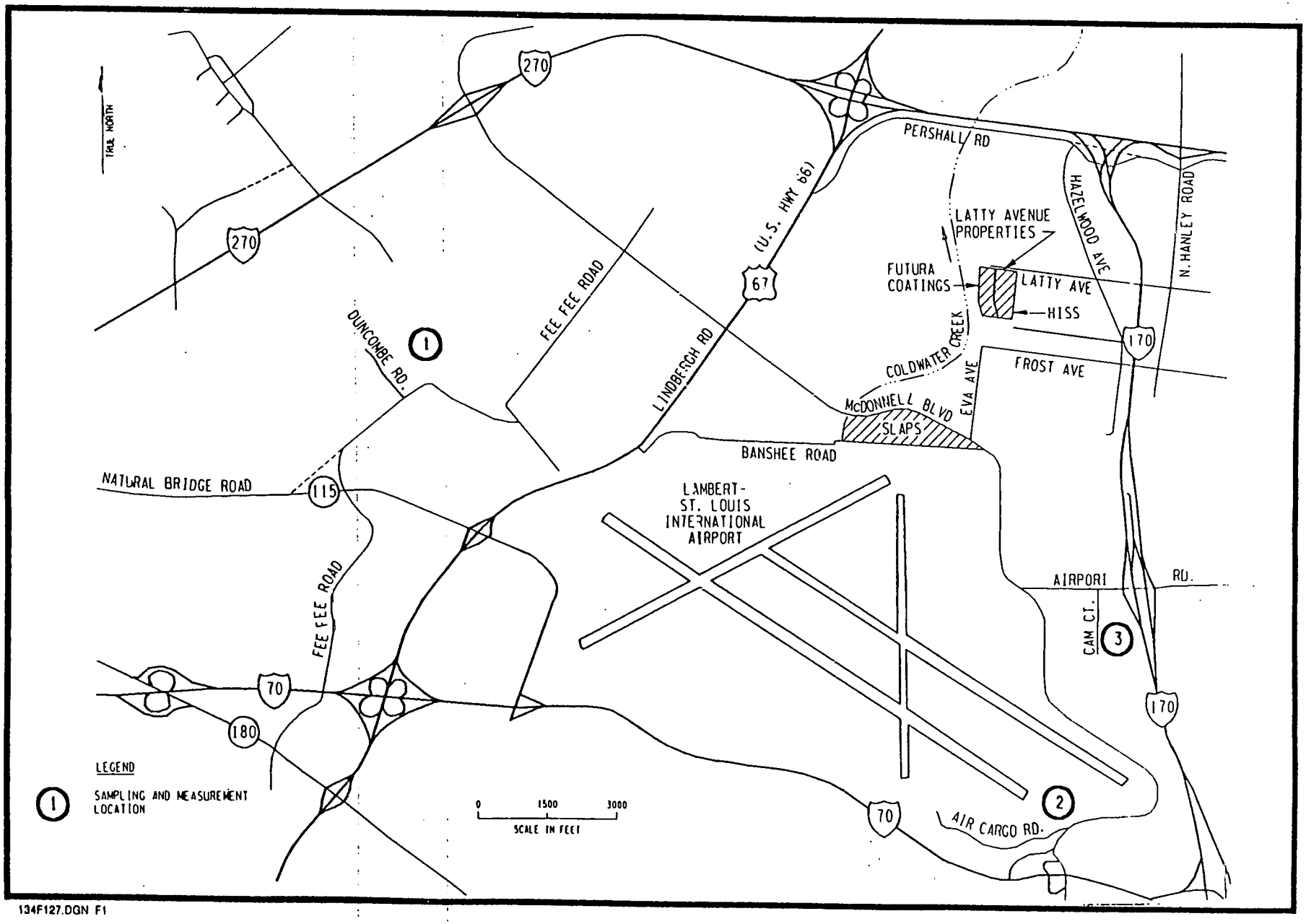


FIGURE 2-19 URANIUM PROCESSING AT SLDS



134F127.DGN F1

FIGURE 2-20 BACKGROUND SAMPLING AND MEASUREMENT LOCATIONS IN THE ST. LOUIS AREA

SLDS NORTH
TRUE NORTH

▲ SAMPLE LOCATION AT WHICH RESULTS DID EXCEED CLEANUP GUIDELINES
■ SAMPLE LOCATION AT WHICH RESULTS DID NOT EXCEED CLEANUP GUIDELINES

E 900 E1100 E1300 E1500 E1700 E1900 E2100 E2300 E2500 E2700 E2900 E3100 E3300 E3500 E3700 E3900
N2400 N2200 N2000 N1800 N1600 N1400 N1200 N1000

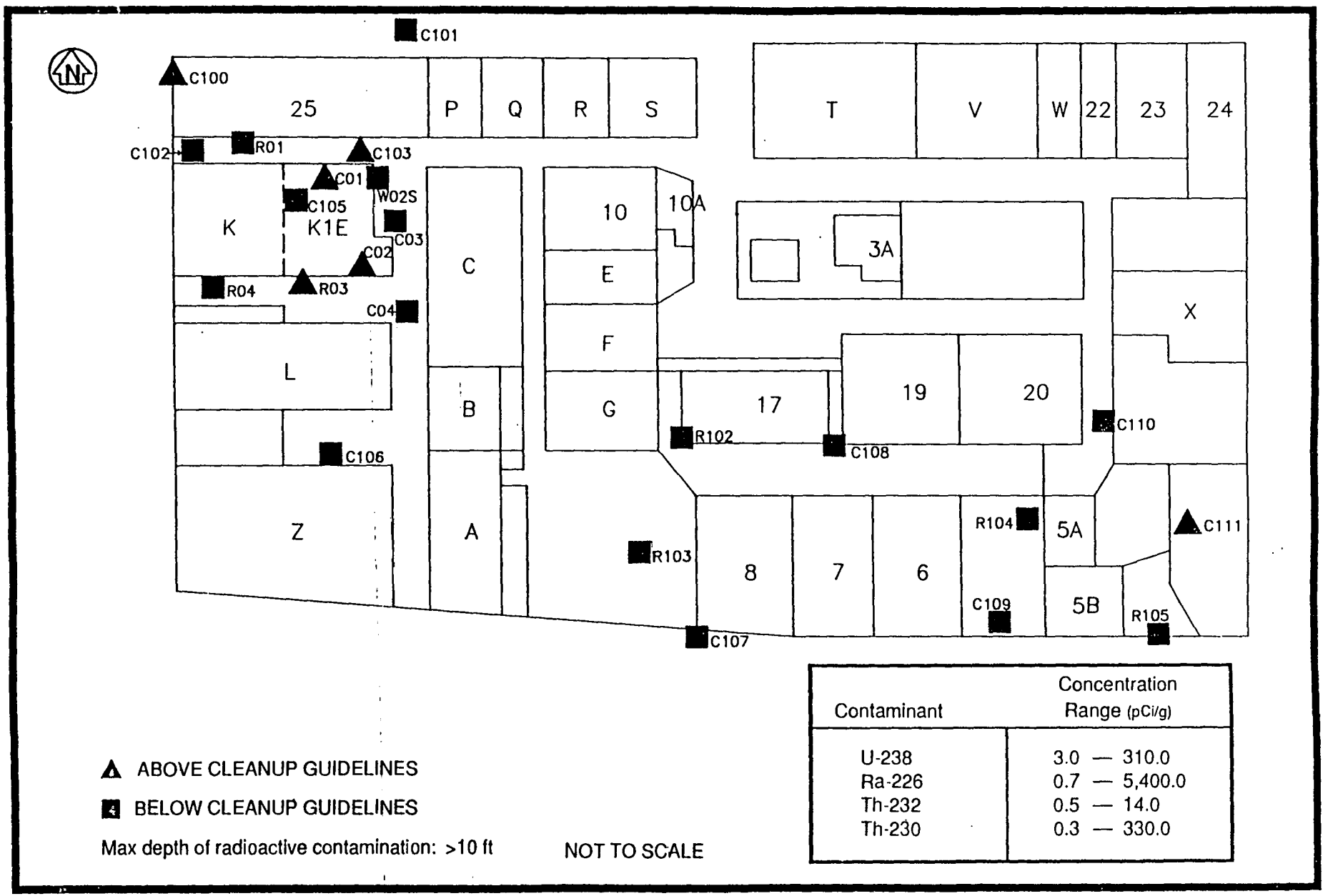
PLANT NO. 9
PARKING LOT
McKINLEY BRIDGE
SALISBURY ST.
PLANT NO. 8
PARKING LOT
PARKING LOT
PLANT NO. 1
HALL ST.
CITY OF ST. LOUIS PROPERTY
MALLINCKRODT ST.
PLANT NO. 2
PLANT NO. 6
NORTH BROADWAY
PLANT NO. 3
DESTREHAN ST.
PLANT NO. 6E
PLANT NO. 7N
PLANT NO. 7W
PLANT NO. 7E
PLANT NO. 5
PLANT NO. 7S
MISSISSIPPI RIVER
ANGELRODT ST.

NORFOLK & WESTERN RAILROAD
ST. LOUIS TERMINAL RAILROAD ASSOCIATION
CHICAGO, BURLINGTON, & QUINCY RAILROAD

APR 3, 1989

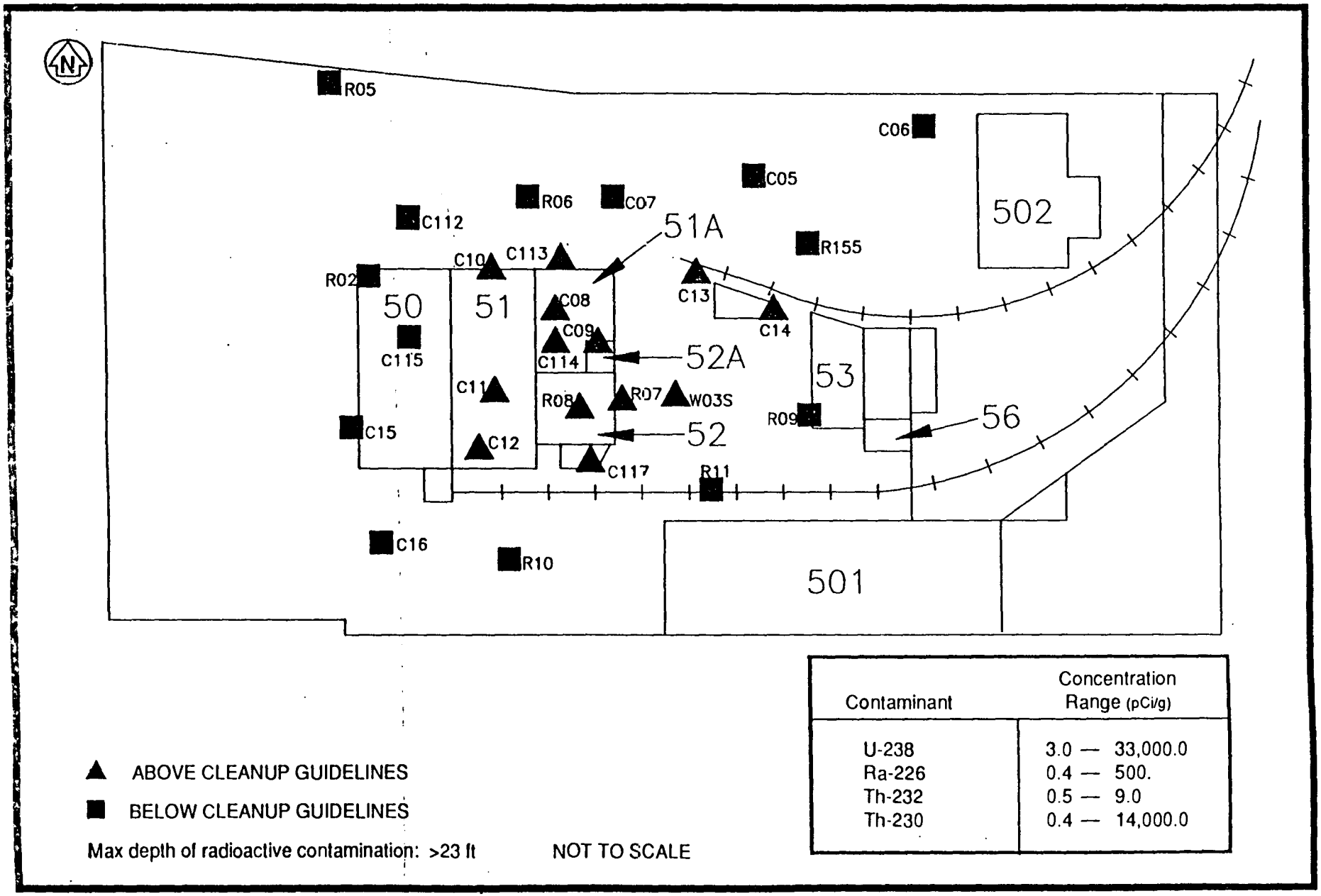
116F022.DGN BORE

FIGURE 2-21 LOCATIONS OF BOREHOLES AT SLDS



Contaminant	Concentration Range (pCi/g)
U-238	3.0 — 310.0
Ra-226	0.7 — 5,400.0
Th-232	0.5 — 14.0
Th-230	0.3 — 330.0

FIGURE 2-22 RADIOLOGICAL ANALYSIS RESULTS FOR SOIL AT PLANT 1



Contaminant	Concentration Range (pCi/g)
U-238	3.0 — 33,000.0
Ra-226	0.4 — 500.
Th-232	0.5 — 9.0
Th-230	0.4 — 14,000.0

FIGURE 2-23 RADIOLOGICAL ANALYSIS RESULTS FOR SOIL AT PLANT 2

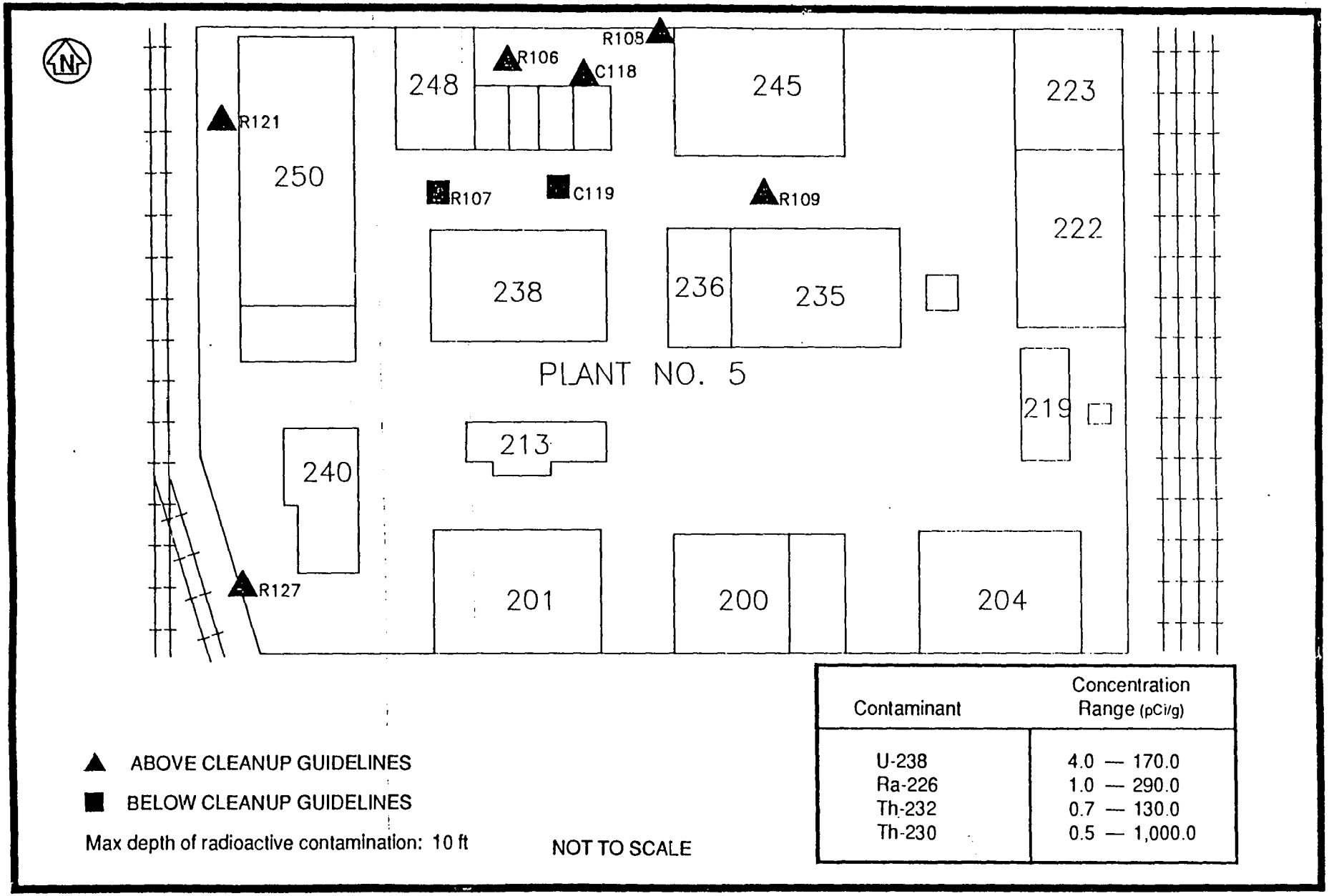
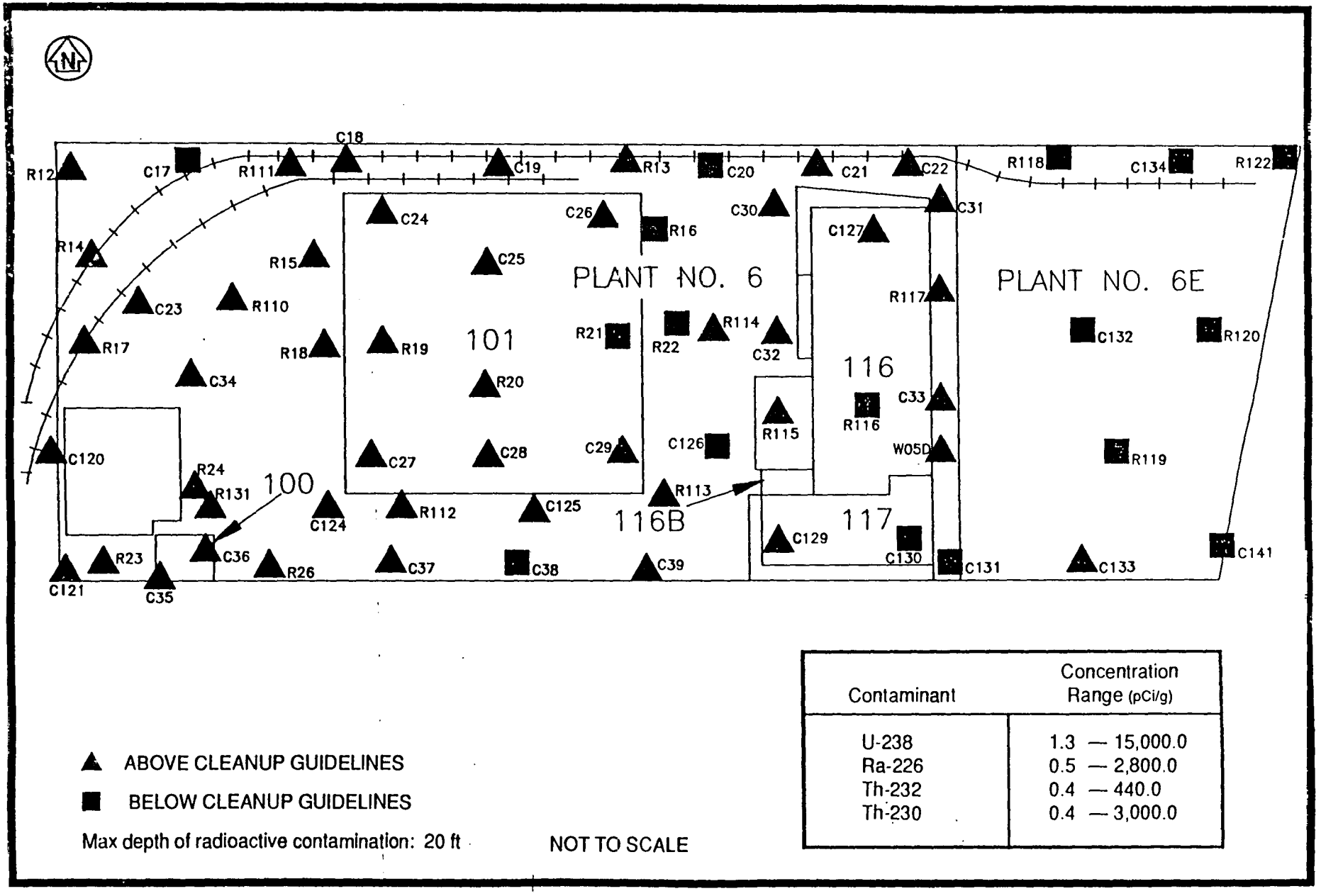


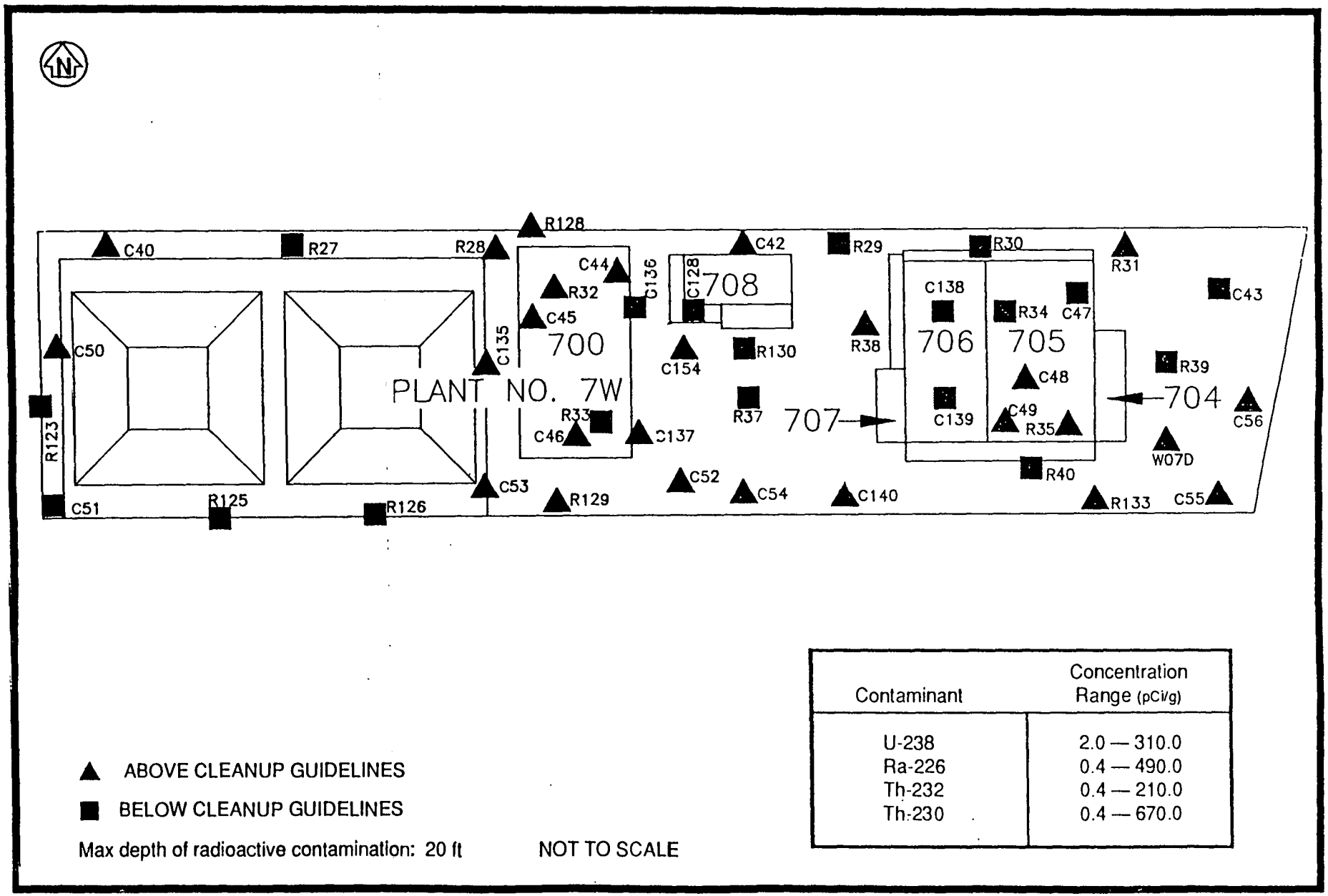
FIGURE 2-24 RADIOLOGICAL ANALYSIS RESULTS FOR SOIL AT PLANT 5

4.14-1097.3
B2:DSSOIL5:V1



Contaminant	Concentration Range (pCi/g)
U-238	1.3 — 15,000.0
Ra-226	0.5 — 2,800.0
Th-232	0.4 — 440.0
Th-230	0.4 — 3,000.0

FIGURE 2-25 RADIOLOGICAL ANALYSIS RESULTS FOR SOIL AT PLANTS 6 AND 6E



Contaminant	Concentration Range (pCi/g)
U-238	2.0 — 310.0
Ra-226	0.4 — 490.0
Th-232	0.4 — 210.0
Th-230	0.4 — 670.0

▲ ABOVE CLEANUP GUIDELINES

■ BELOW CLEANUP GUIDELINES

Max depth of radioactive contamination: 20 ft NOT TO SCALE

FIGURE 2-26 RADIOLOGICAL ANALYSIS RESULTS FOR SOIL AT PLANT 7

4.14-1097.5
R2:BSSOIL7:V1

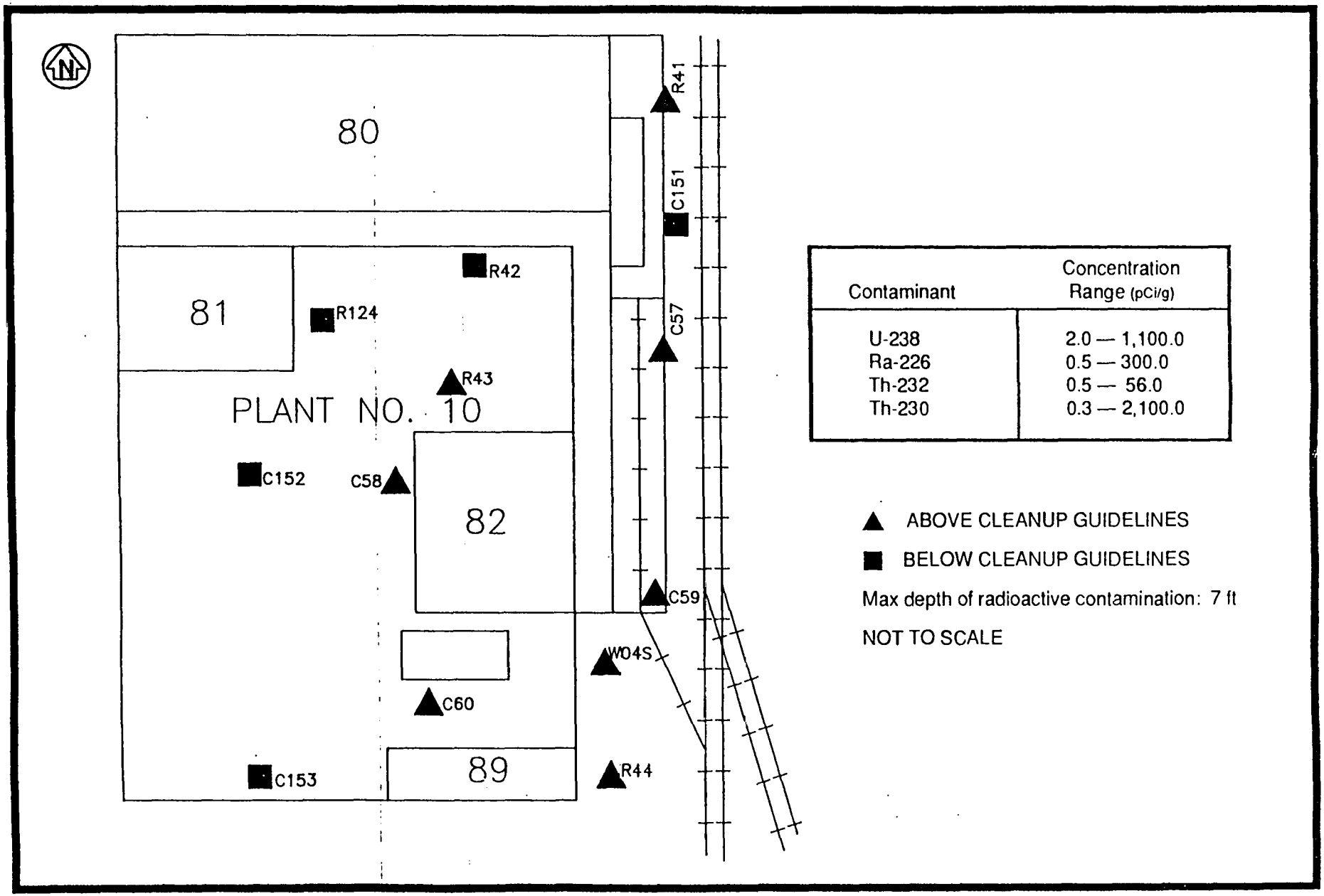
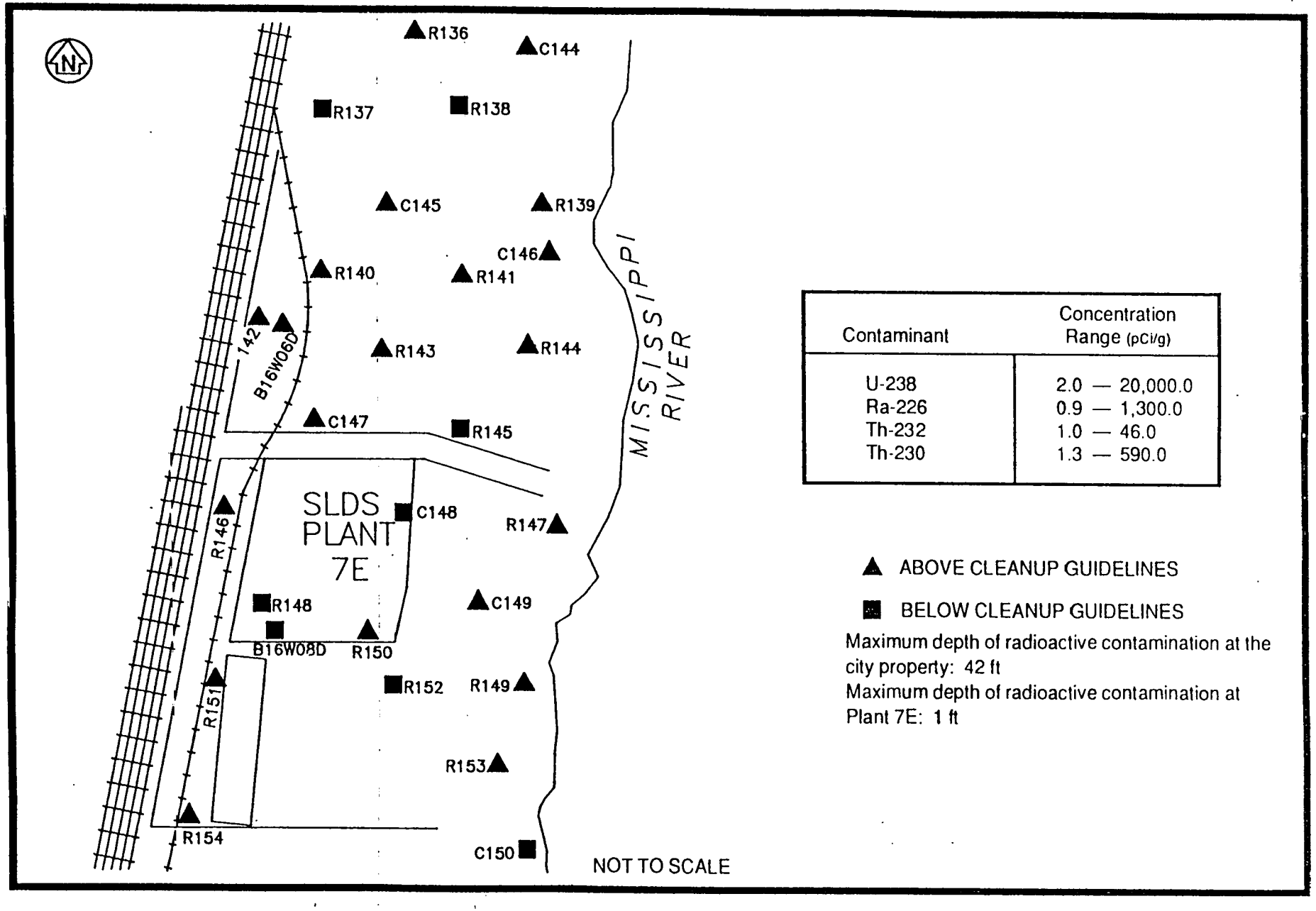


FIGURE 2-27 RADIOLOGICAL ANALYSIS RESULTS FOR SOIL AT PLANT 10



Contaminant	Concentration Range (pCi/g)
U-238	2.0 — 20,000.0
Ra-226	0.9 — 1,300.0
Th-232	1.0 — 46.0
Th-230	1.3 — 590.0

FIGURE 2-28 RADIOLOGICAL ANALYSIS RESULTS FOR SOIL AT THE CITY PROPERTY AND PLANT 7E

3.0 INITIAL SITE EVALUATION

This section presents results of the initial site evaluation. Available characterization and monitoring data were used to perform a preliminary assessment of potential risk to human health and impacts to the environment from exposure to site contaminants. The purpose of this initial evaluation was to allow identification of any potential near-term health and environmental threats at the site and of any other potentially significant pathways of exposure warranting more detailed evaluation. A comprehensive baseline risk assessment will be conducted to assess these potentially significant pathways; results will be published in a baseline risk assessment report.

Because certain properties comprising the St. Louis site have unique characteristics with respect to the extent of contamination, land use, and environmental setting, the affected properties were further categorized into three groups to afford a more efficient and meaningful preliminary evaluation of the risks posed by contaminants. The three groupings are (1) SLDS and SLDS vicinity properties; (2) SLAPS and HISS; and (3) "other properties."

3.1 PRELIMINARY SITE ASSESSMENT OF POTENTIAL HUMAN HEALTH IMPACTS

This section summarizes potential human exposure to site contamination for both current and future land use conditions at the different areas comprising the site.

3.1.1 St. Louis Downtown Site and Vicinity Properties

SLDS is located in a highly industrialized area, and the numerous buildings and facilities that comprise the 10 plant areas are currently used for the production of specialty chemicals. Because of its past direct involvement in processing uranium ores, elevated levels of contamination are present on the property. Most of the contamination, however, is found under buildings and asphalt or concrete and is therefore not accessible to humans. Access to the property is limited to plant employees, and human activity there is substantial because SLDS is an operating industrial facility. Plant health and safety staff and DOE currently monitor activities and conditions at the plant to ensure that inadvertent exposure to contaminants does not occur or is minimal.

The primary source of contamination at SLDS is soil underneath buildings or paved areas. An estimated 220,200 m^3 (288,000 yd^3) of soil is contaminated, extending to depths of approximately 6 m (20 ft). Some contamination also exists inside buildings and drains. Contaminants in soils are

radioactive and chemical in nature and include radionuclides in the uranium, thorium, and actinium decay series and inorganic (i.e., metals) and organic (i.e., PAH) compounds. Contamination inside buildings has been found to be mainly surface, nonremovable or removable, radioactive contamination and airborne radon decay products. Because of ongoing operations at SLDS, the extent of contamination in each drainage pathway will be determined when final building surveys are conducted, just prior to remediation.

Several groundwater samples from this property (ORNL 1981) contain uranium levels that exceed the water ingestion guideline in DOE Order 5400.5 (DOE 1990a). Additionally, various metals and some organic compounds (e.g., benzene) are present at levels exceeding federal drinking water standards.

Six SLDS vicinity properties have also been investigated; three are railroad properties running north and south through SLDS, and three are commercial properties that border SLDS to the north and south. A portion of one vicinity property was formerly used as part of the MED/AEC activities conducted at SLDS; past use of the other vicinity properties is unknown. Contaminant levels at the SLDS vicinity properties are variable, with the highest levels of radioactivity found on the property adjacent to SLDS Plant 7.

Current risk

Under current conditions, because the primary sources of contamination at SLDS are either located underneath substantial cover (i.e., buildings, concrete, or asphalt) or are inaccessible (i.e., contaminated drains), exposure to existing contamination may only occur for persons working inside plant buildings due to potential inhalation of radon and its decay products and exposure to external gamma radiation emanating from the soil underneath the buildings. Intrusion into the soil could also expose workers. Groundwater in the area is not used as a drinking water source or household supply. Though there may be limited industrial use of groundwater, this use does not generally involve substantial human contact with the water and is not considered to present significant risks.

Current exposure pathways at the SLDS vicinity properties are similar to those at SLDS, except for contaminated structures, which do not exist at the vicinity properties and therefore are not a consideration.

Future risk

Because of the extensive industrial use of the immediate areas surrounding SLDS and its vicinity properties, it is anticipated that these properties will remain industrial in the future. Based on this assumption and other factors such as potential loss of site protective measures (i.e., access controls, monitoring programs, and waste containment measures), the potential for exposure to existing contaminants may be greater and include additional pathways in the future. In addition, ingrowth and decay of radionuclides might significantly change the mix of contaminants in the future, altering the risks. There may be exposure via inhalation of contaminated airborne dust, inhalation of radon and its decay products, incidental ingestion of contaminated soil, and external gamma radiation fields present.

3.1.2 St. Louis Airport Site and Hazelwood Interim Storage Site

These two properties (including the ditches surrounding SLAPS) have several characteristics in common: both contain relatively high levels of contamination resulting from their use for storage of radioactive materials; both areas are fenced to preclude unauthorized access; and both have been subject to routine environmental monitoring programs implemented by DOE. Minimal human activity, other than routine site surveillance and maintenance activities, occurs at either area. In addition, as discussed earlier in this work plan, both areas have been characterized for radioactive and nonradioactive contaminants.

The primary source of contamination at these two properties is soil, both surface and subsurface. Soil contamination at SLAPS extends to a depth of 5.5 m (18 ft); at HISS contamination has been detected down to 1.8 m (6 ft). The volume of the two covered waste piles of contaminated material at HISS (which consist mainly of soil) is approximately 24,500 m^3 (32,000 yd^3).

Groundwater in several shallow wells at SLAPS contains uranium at concentrations 4 to 6 times the water ingestion guideline in DOE Order 5400.5. Several wells at HISS also contain uranium at levels greater than background levels, but not exceeding the DOE water ingestion guideline. However, as at SLDS, the groundwater in the area is not used for drinking water or for household supplies, so there are no current human receptors.

Current risk

Under current conditions, potential pathways for exposure at both properties include inhalation of radon in ambient air, inhalation of contaminants from resuspended dust, ingestion of contaminants in soil, direct dermal exposure to contaminated soil, and exposure to external gamma radiation. Direct exposure to or ingestion of contaminants in the waste piles at HISS is not a current exposure pathway because these piles are covered and monitored.

Although there is potential for exposure via the aforementioned pathways, current human exposure is limited because only a few trained personnel are employed at the properties and adequate access controls (i.e., fences) are in place. Additionally, a monitoring program ongoing since 1984 has indicated that external gamma exposure and radon levels do not exceed DOE radiation protection guidelines. However, radon-222 levels at locations along the fenceline have, at times, exceeded Missouri radiological regulations for unrestricted access areas.

Future risk

In considering future risks at SLAPS and HISS, it is assumed that site protective measures may no longer exist and that land use in these areas may be residential. The shift in land use could increase exposures via the relevant pathways. Direct dermal exposure to site soils, enhanced exposure to external gamma radiation fields, emissions of radon and subsequent inhalation of radon decay products, ingestion and inhalation of contaminated site soils, and ingestion of contaminated homegrown produce are all potential exposure pathways. As appropriate, these pathways will be quantitatively assessed as part of the baseline risk assessment.

3.1.3 Other Properties

These properties include the ball field area across from SLAPS to the north, the Futura Coatings property, commercial vicinity properties associated with SLAPS and Latty Avenue, residential vicinity properties, railroad vicinity properties, haul roads, the SLDS city property, and Coldwater Creek. The primary source of contamination at all of these properties is soil.

The baseline risk assessment will address potential radiological and chemical risks associated with current and future land uses at these properties. Quantitative assessment will be performed for radiological risks for all these properties; however, quantitative assessment for chemical risks will be performed only for the Futura Coatings property, the ball field area, and the SLDS city property

because these properties have been characterized for chemical contaminants, too. A qualitative assessment for chemical risks at the remaining properties included in this grouping will also be included in the baseline risk assessment, assuming that chemical levels at these properties are equal to or less than those at the source areas or SLAPS and HISS. Potential risks associated with current and future land use for these properties are discussed below.

Ball field area

Soil at this property has been characterized for both radioactive and chemical constituents. In one isolated location, radioactive contamination extends to a depth of 3 m (10 ft), but most contamination is in the upper foot of soil. Chemical concentrations are lower in the ball field soils than in other areas where chemical levels have been characterized. Although there is currently a "No Trespassing" sign posted on the property, the area is not fenced and may occasionally be used for recreational activities. Potential current risks at the ball field area would be associated with inhalation of radon, inhalation of contaminants from resuspended dust, ingestion of contaminants in soil, direct dermal exposure to contaminated soil, and exposure to external gamma radiation. Preliminary estimates of current risks posed by using the area indicate that radiological dose is comparable to that received from natural background sources (BNI 1990b); more detailed assessment of risks will be conducted as part of the baseline risk assessment. Future risks would be associated with residential occupancy and the same pathways as were given for future residential use of the SLAPS or HISS areas.

Futura Coatings and other commercial properties

Because the Futura Coatings property was formerly used as a storage area for wastes from SLDS and SLAPS operations, this area has the highest contaminant levels of all areas categorized as other properties. Radionuclide and inorganic compound contamination in soil extends to a depth of 4.6 m (15 ft). Current radon-222 measurements in Futura buildings indicate levels comparable to those in ambient air. Contaminants at the other commercial properties are generally at lower concentrations and are not found at depths greater than 1 m (3 ft). Because these properties are currently used for commercial purposes and employees are on site regularly, current potential risks are associated with inhalation of radon, inhalation of contaminants from resuspended dust, ingestion of contaminants in soil, direct dermal exposure to contaminated soil, and exposure to external gamma

radiation. Future risks and pathways at Futura and commercial vicinity properties associated with SLAPS and Latty Avenue would be the same as those associated with residential occupancy. Because of their proximity to SLDS, commercial land use at the SLDS commercial vicinity properties is more plausible. Future risks at these properties would be associated with future employees through the same aforementioned pathways.

Residential vicinity properties

Contamination at seven nearby residential properties is along the roadsides, at depths of 0.6 m (2 ft) or less. Current and future risks from these small areas of contamination are minimal because exposure opportunities are limited. Nonetheless, exposure is possible via inhalation of radon and/or resuspended dusts from these areas, ingestion of soil, direct dermal exposure to soil, and external gamma radiation.

Railroad vicinity properties

Radiological characterization of seven railroad properties in the vicinity of SLAPS and HISS indicates contamination generally extending to 1 m (3 ft) or less, with contamination at one location extending to a depth of 2 m (7 ft). Railroad workers are not known to spend a significant amount of worktime in these areas; however, the baseline risk assessment will assess potential exposure to a worker who spends a limited amount of time on the most contaminated of the railroad properties. Potential exposure at the railroad properties would be via external exposure, dust inhalation, incidental ingestion, inhalation of radon, and direct dermal exposure. Future risks would be associated with residential occupancy and the same pathways listed above.

Haul roads

Soil beneath the road and at the edges of the main roads that were used for transportation of wastes to and from SLAPS and HISS contains elevated levels of radionuclides. At one haul road (McDonnell Boulevard), the contamination extends to a depth of 4.5 m (15 ft), but contamination is generally confined to the upper 1 m (3 ft) of soil. Substantial human exposure along these roads is not expected to occur because much of the contamination is beneath the pavement and human receptors do not spend significant amounts of time near the contaminated areas of the haul roads. However, there is potential for limited exposure to haul road contamination via inhalation of radon

and/or dusts, ingestion of soil, dermal contact, and direct exposure to external gamma radiation. Future risks would be associated with residential occupancy and these pathways.

SLDS city property

This property, adjacent to SLDS, is contaminated to a depth of 12.6 m (42 ft). The city property is not fenced and is accessible to the general public, although apparently is not often used by the public. Current potential exposure to contaminants exists via inhalation of radon and/or dusts, ingestion of soil, dermal contact with soil, and direct exposure to external gamma radiation. There are no buildings on this property. Furthermore, because of its proximity to SLDS, future risks would be associated with employees at a future commercial establishment on this property. The pathways would be similar to those given for future use of the SLDS vicinity properties.

Coldwater Creek

Sediments in Coldwater Creek and soil along the banks contain elevated levels of radioactive contaminants to a depth of 0.3 m (1 ft); the highest levels are found in the stretch of the creek between SLAPS and Pershall Road, but some contamination exceeding guidelines extends past Pershall Road. Current and future exposure is possible via ingestion or dermal contact with sediments or soil along the banks.

3.2 ECOLOGICAL IMPACTS

Because the majority of the St. Louis site is located in industrial areas, species found on site are probably affected by site-related contamination as well as other sources of contamination. Although there are no known critical habitats or threatened and endangered species at the site, some wildlife habitats do exist. Aquatic habitats potentially affected include Coldwater Creek and its drainages. Coldwater Creek is polluted by runoff both upstream and downstream of SLAPS and HISS.

Based on current land use, impact to site environment from site contaminants is expected to be similar to that typically encountered at industrial sites. Some contaminants in the soils (e.g., several metals) are at concentrations that have been found to adversely affect wildlife in laboratory and field experimental conditions. However, the mobility of species that inhabit the site, coupled with similar (nonradioactive) contaminants throughout the urban area, render a quantitative assessment of the

environmental impacts of the site to wildlife impracticable. However, qualitative assessment of environmental impacts at the St. Louis site will be included in the baseline risk assessment report prepared for the site. If the potential for adverse impacts to wildlife is identified for the St. Louis site, these impacts would occur only at the level of the individual. No impacts of ecological significance (i.e., impacts that would occur at the population or community level) would be expected.

3.3 TOXICOLOGICAL AND ENVIRONMENTAL PROPERTIES OF SELECTED CONTAMINANTS

As background information for this work plan, a general description of the toxicological effects associated with radiation exposure and brief descriptions of the major toxicological effects of selected chemical contaminants associated with the St. Louis site are presented in Subsections 3.3.1 and 3.3.2. For most of the contaminants identified, the potential is greater for chronic (long-term) than for acute (short-term) effects of humans and biota under current site conditions.

3.3.1 Radiation Toxicity

Radiation exposures at the St. Louis site are all classified as low level. For these low-level exposures, dose rates are relatively close to background radiation levels; exposure periods of several years to a lifetime are usually required to accumulate significant doses; and health effects, if they appear, are difficult to discern from naturally occurring incidence rates.

Radiation health effects for humans have only been confirmed at relatively high dose rates or with large populations. For low doses, health effects are presumed to occur but can only be estimated statistically. Risk estimates are strictly applicable only to large populations because the appearance of an effect after an exposure is a chance event.

Medical practice has shown that the body has mechanisms to repair radiation-damaged cells. It is believed that these mechanisms probably operate for low-level radiation exposure where doses and dose rates are low, but this has not been confirmed.

The potential health effects associated with exposures at the St. Louis site are somatic, primarily increased risks of various types of cancer in the exposed individual. Studies with insects and animals have also shown that the offspring of exposed subjects may be affected, but such effects have not been established for humans. The sources of increased risk are emissions of alpha and beta particles and gamma and X rays from decay products in the thorium, uranium, and actinium decay chains. The potential contaminants of concern are discussed in Subsection 3.4.1.

Exposure pathways are either external or internal. External exposure occurs when the radioactive material is outside the body. Gamma rays and X rays are emitted and then enter the body by penetrating tissue, exposing internal organs. Beta particles can sometimes cause external exposure but only to the skin. Alpha particles are almost never an external exposure problem because generally their energy is dissipated in dead skin cells before they can penetrate to live skin cells. Internal exposure occurs when the radioactive material enters the body by inhalation or ingestion. Inhaled material can be exhaled, deposited in the lungs, expelled from the lungs to be spit or swallowed and excreted, or taken up by the blood and relocated to other organs and excreted over time. Ingested material enters the blood and is either expelled in the urine or feces or relocated to other organs and excreted over time. For internal exposures, alpha and beta particles are the dominant concern because their energy is absorbed in cells before the particles leave the body. Gamma rays and X rays are most likely to leave the body without depositing a large fraction of their energy.

Except for the way they are created, X rays and gamma rays are similar; both are photons, i.e., waves with particulate properties. Gamma rays generally have higher energies than X rays, and gamma rays are emitted by the atomic nucleus whereas X rays are emitted outside the nucleus. Both are primarily an external hazard because they can easily penetrate tissue; they can reach internal organs, making them an internal hazard as well.

Alpha particles are helium nuclei (two protons bound to two neutrons) and are the most effective radioactive emission in damaging cells because they lose their energy rapidly over very short distances. Alpha particles are almost exclusively an internal hazard because, for external exposure, they generally lose all their energy in the dead skin cell layer of the body before reaching living tissue. Within the body, alpha particles are quickly stopped by living cells.

Beta particles are electrons and are intermediate in their effectiveness in damaging cells because they lose their energy over longer distances. Beta particles are primarily an internal hazard; however, in cases of external skin exposure, beta particles can penetrate to living skin cells, thus representing an external hazard as well.

For inhalation of any of the radionuclides listed as potential contaminants of concern in Subsection 3.4.1, the lungs are the primary organ of health concern. For soluble materials, additional critical organs are the kidneys and whole body for uranium. For ingestion of the potential contaminants of concern, excluding radon, the bones and gonads are the primary organs of health concern. For ingestion of additional soluble materials, the kidneys and the whole body are critical organs for uranium (Eckerman et al. 1988; ICRP 1978).

3.3.2 Chemical Toxicity

Based on data acquired to characterize chemical contamination at the St. Louis site, it has been determined that in addition to thorium, uranium, and radium, other metals have been found at the site in above-background concentrations. Organic constituents have also been detected at the site; soil samples from SLDS contain elevated concentrations of PAHs, and VOCs were found both in soil and groundwater samples. Sampling the remaining properties (i.e., selected vicinity properties) for organics indicated the presence of a few VOCs at levels potentially consistent with anthropogenic background levels in the area.

Metals found at the site include cadmium, cobalt, molybdenum, nickel, and thallium. Metal compounds can undergo a wide range of transformation processes, forming complexes with inorganic species or organic ligands present in the environment. These processes, collectively referred to as speciation, can occur in all environmental media. The speciation of a metal in a given environment affects its bioavailability, solubility, volatility, and sorptive properties. In addition to speciation, the fate of metals is affected by the properties of the environmental media. For example, properties affecting the mobility of a metal compound in soil include the cation exchange capacity and pH of the soil; the solubility of a metal in water depends on the presence of other chemical species and on the pH.

Some of the metals present in St. Louis site soils can be toxic after inhalation, ingestion, or dermal contact. Most toxicity that humans have experienced is associated with high-level industrial exposures or past medicinal use of metal compounds, and not with exposure to elevated metal levels in soils. At sufficient levels of intake, some of the metals can cause nerve degeneration and kidney, liver, or cardiac injury. Additionally, inhalation of the dusts of some metals has been associated with lung disease and lung cancer. Exposure to some metals may induce teratogenic and other reproductive effects.

The PAHs such as those found in soil samples from SLDS are typical of an industrialized area. PAHs are widely distributed in the environment, occurring in sediments, soils, air, and surface waters. These compounds are highly soluble in adipose tissue and lipids; however, most PAHs taken in by mammals are readily metabolized and excreted. As a class, PAHs have diverse biological effects and varying carcinogenic potential.

3.4 CONCEPTUAL SITE MODEL

Information from the initial evaluation is combined and depicted in a conceptual model for each group of properties (see Figures 3-1, 3-2, and 3-3). The conceptual models incorporate information on the primary sources of contamination, potential release and transport, potential routes of exposure or pathways, and potential receptors for contaminants found in the affected properties comprising the St. Louis site.

3.4.1 Potential Contaminants of Concern

At all areas of the St. Louis site, the primary contaminants of concern include radionuclides in the uranium, thorium, and actinium decay series (see Figures 3-4, 3-5, and 3-6). From characterization data, it can also be concluded that there are chemical contaminants in the form of metals (i.e., antimony, arsenic, beryllium, lead, nickel, and thallium) at SLDS, SLAPS, HISS, Futura, and the ball field area. Additionally, PAH compounds have been detected at elevated levels at SLDS.

3.4.2 Potential Release and Transport

At SLDS, most contaminated soils are currently covered with impervious materials. However, in areas where there is no soil cover (or if the cover is removed in the future), contaminants may be released to air as particulates or as gaseous emissions (e.g., radon gas). Contaminants on building surfaces may also be released to the air. Additionally, contaminants in soils may be carried into groundwater by infiltration of surface water, though this release mechanism is also currently limited because surface water cannot penetrate the soil cover. In the areas with no soil cover, contaminant release via surface runoff and erosion is also possible. Both currently and in the future, possible environmental transport of SLDS contaminants may occur by groundwater or surface water transport and atmospheric dispersion. There may also be potential for direct contact with exposed contaminants and external exposure to gamma fields.

For SLAPS, HISS, and the other properties, the same contaminant release mechanisms and transport routes apply but, because the soils are not covered with concrete or asphalt, these processes are more likely to be occurring currently.

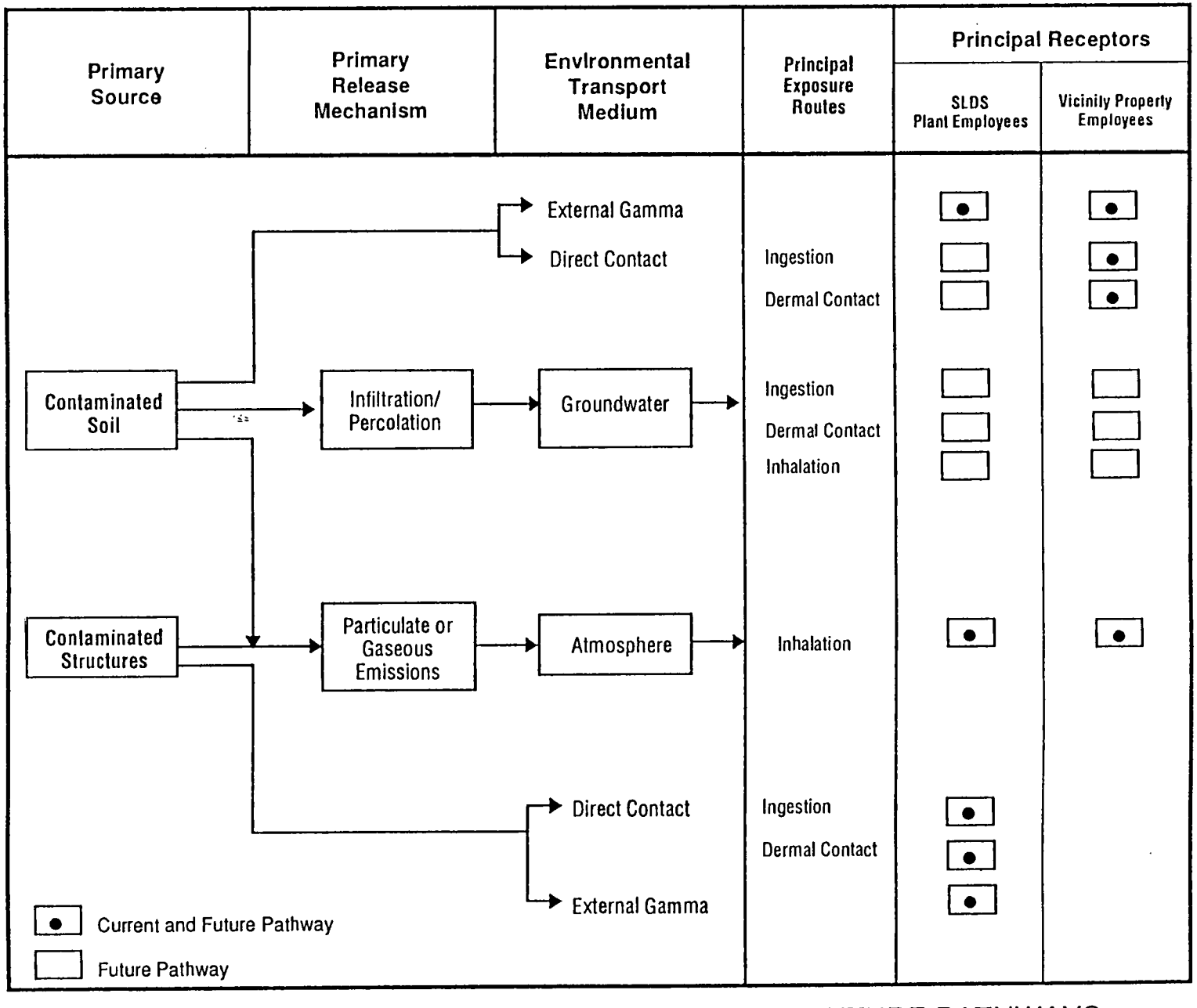


FIGURE 3-1 SITE MODEL FOR CURRENT AND FUTURE PATHWAYS AT SLDS AND VICINITY PROPERTIES

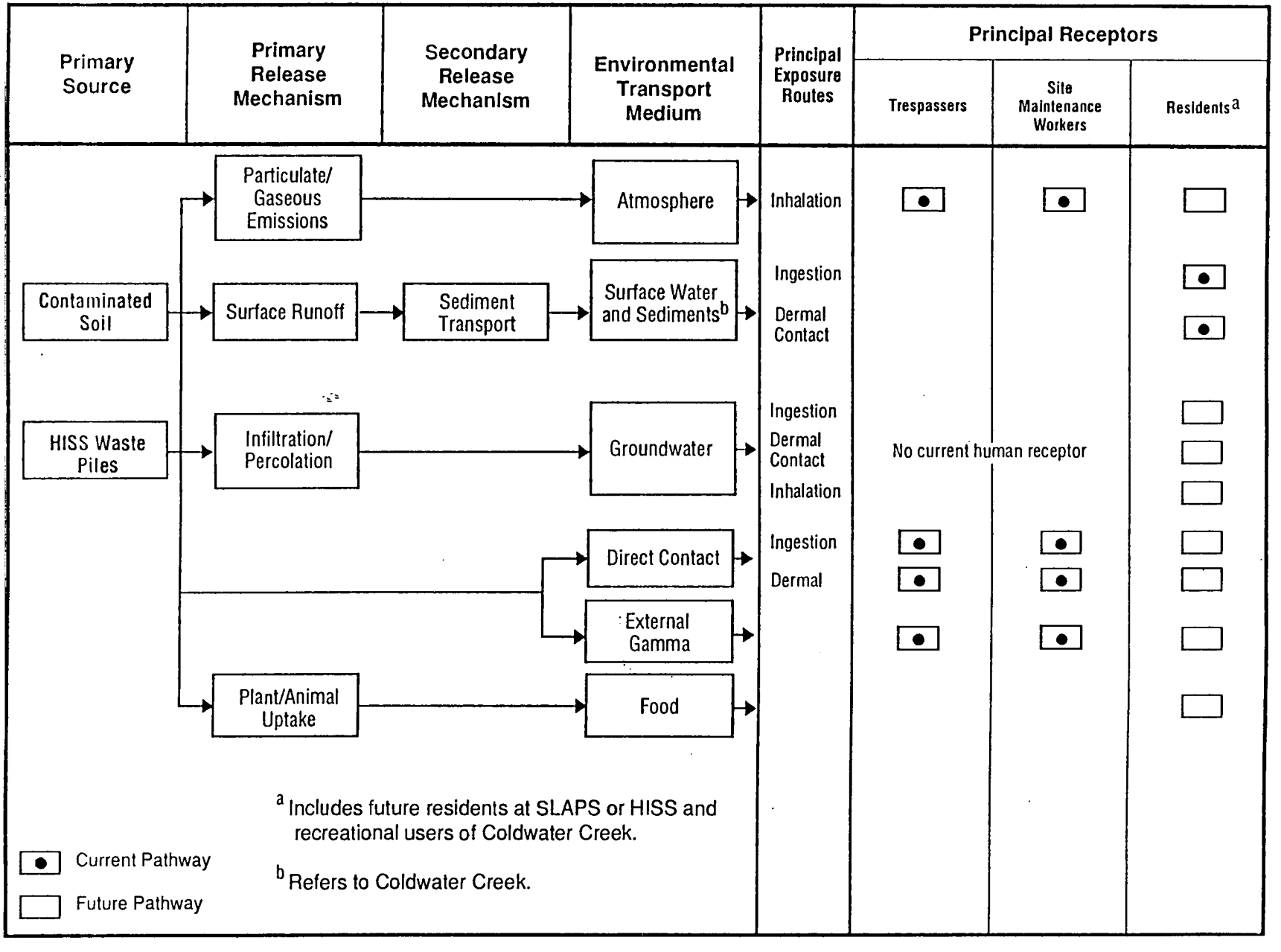


FIGURE 3-2 SITE MODEL FOR CURRENT AND FUTURE PATHWAYS AT SLAPS/HISS

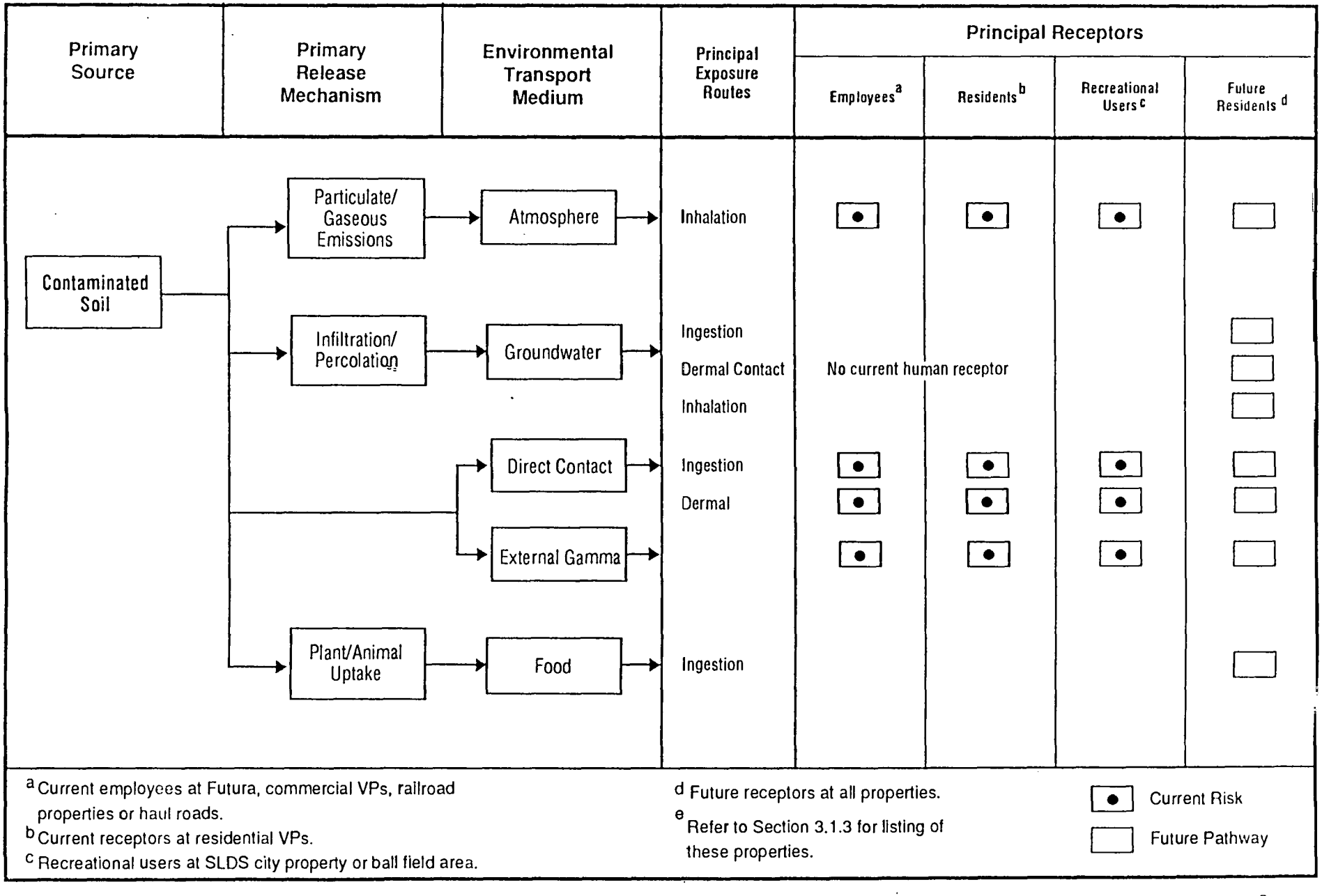


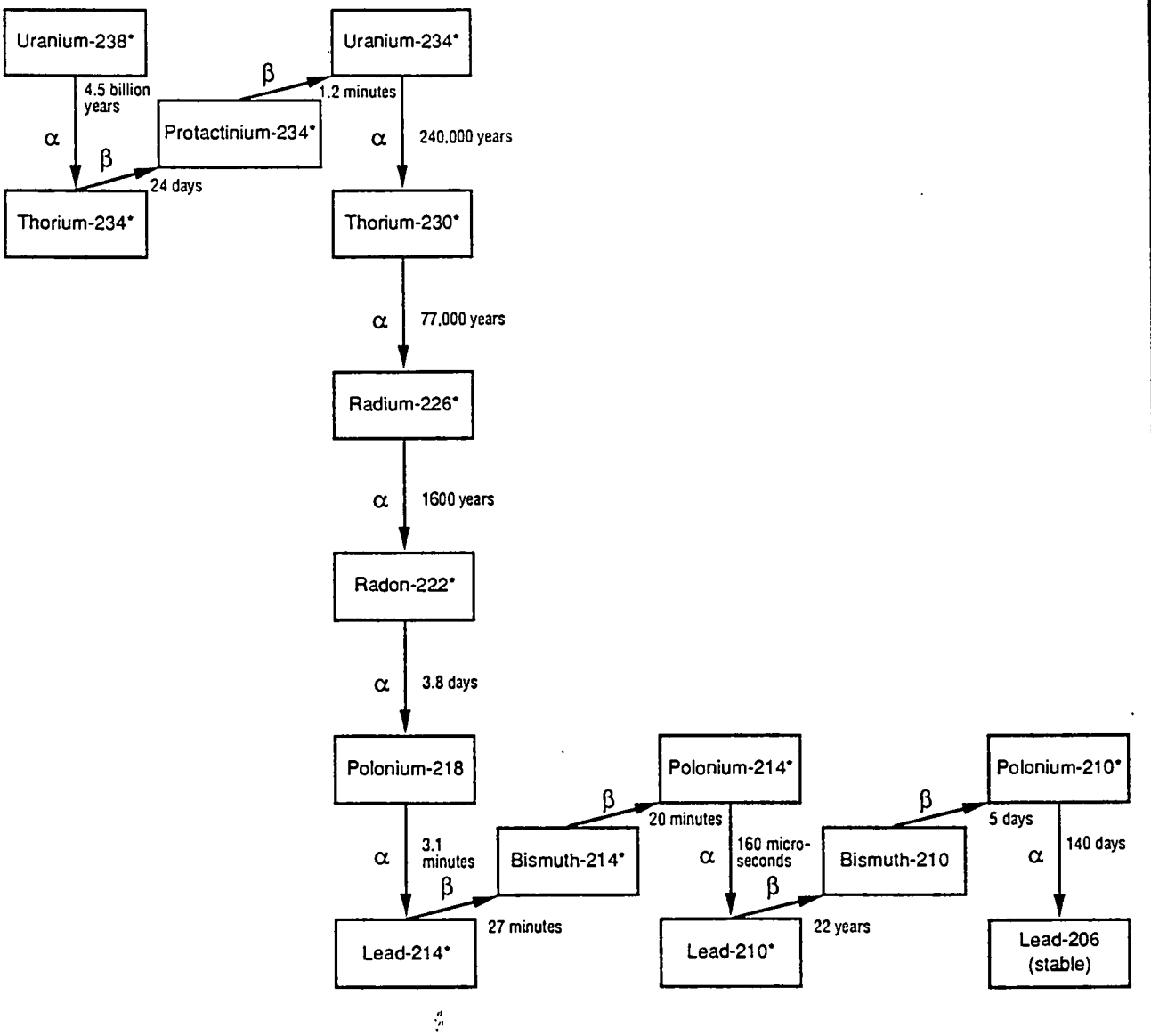
FIGURE 3-3 SITE MODEL FOR CURRENT AND FUTURE PATHWAYS AT OTHER PROPERTIES [e]

3.4.3 Potential Routes of Exposure and Receptors

Concentrations of gaseous and particulate contaminants in air will be the greatest at locations on site. For radon, the concentrations would be greatest inside site buildings. Potential exposure routes for all the areas comprising the St. Louis site are inhalation, ingestion of exposed contaminants (i.e., in soil or on building surfaces), and direct dermal contact with contaminants. At SLDS and its vicinity properties, current potential receptors include employees and possibly recreational users of the contaminated city property adjacent to the plant and the Mississippi River. At SLAPS and HISS, the few workers who maintain these areas are potential receptors but are trained to minimize exposure, so ingestion and dermal contact should be minimal. Trespassers onto these areas may also be exposed via inhalation, ingestion, external exposure, and dermal contact; however, because of the brevity of time spent on site, exposures will be minimal. Potential receptors on the land categorized as "other properties" include employees at commercial properties, recreational property users (e.g., the ball field area), and residents on the properties. All four exposure routes are possible for these receptors. In the future, land use at some of the properties comprising the St. Louis site may change. Potential residential land use of contaminated areas is considered to lead to the greatest magnitude of exposure, although construction workers may experience short-term exposure to higher levels of contaminants.

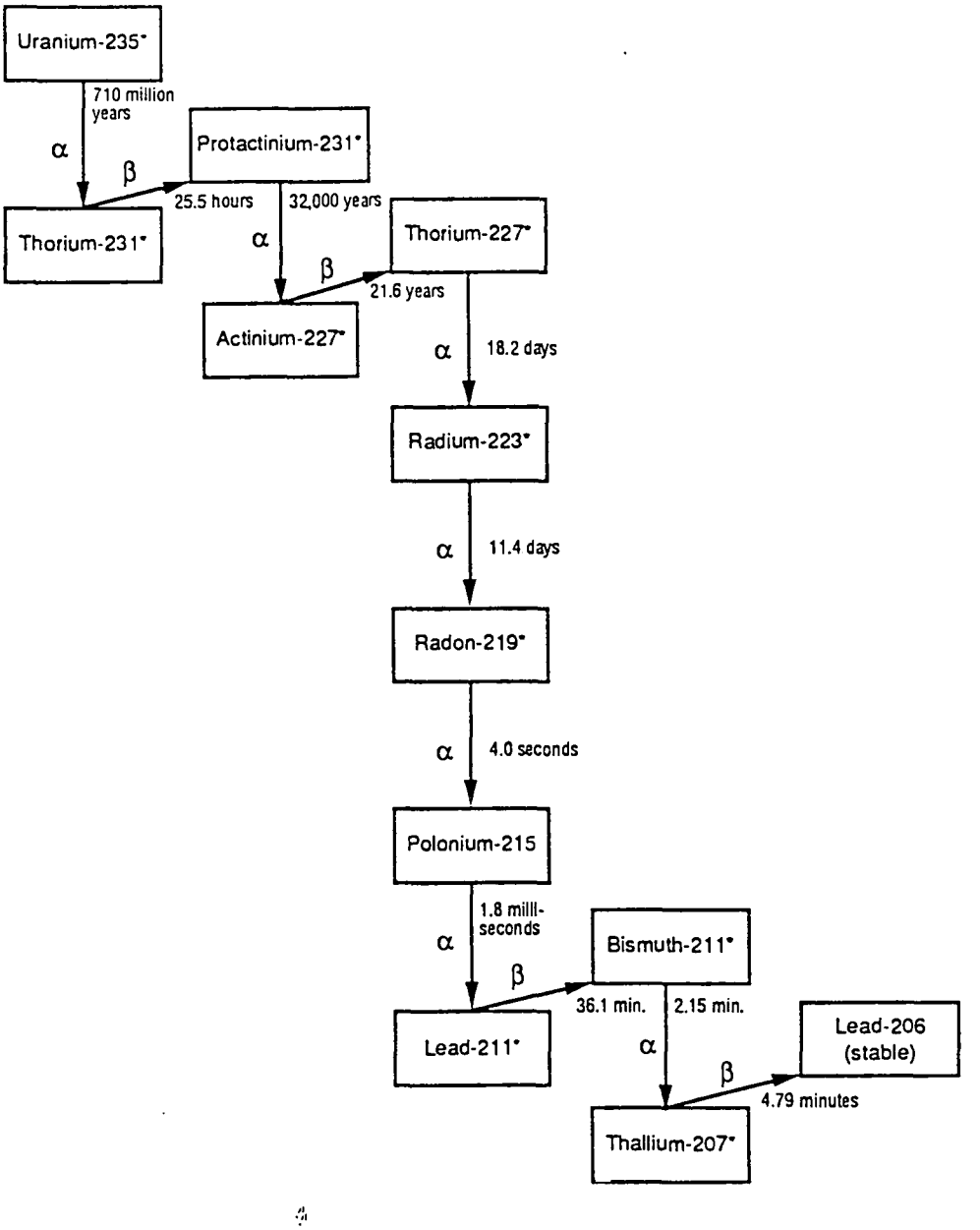
3.5 PRELIMINARY RESPONSE OBJECTIVES AND TECHNOLOGIES

The overall objective of the response action at the St. Louis site (including both removal and remedial actions) is to clean up, stabilize, or otherwise control contamination to ensure protection of human health and the environment. Additional broad objectives, established on the basis of specific criteria identified in CERCLA, as amended, are presented in Subsection 3.5.1. Potential response actions and technologies are discussed in general in Subsection 3.5.2, and preliminary response action objectives that are specific to contaminated environmental media at the St. Louis site are addressed in Subsection 3.5.3 and Appendix B. In Subsection 3.6, general response technologies are assembled into preliminary remedial action alternatives to fulfill the response objectives identified for the site. These objectives, technologies, and alternatives will continue to be developed during the RI/FS-EIS process.



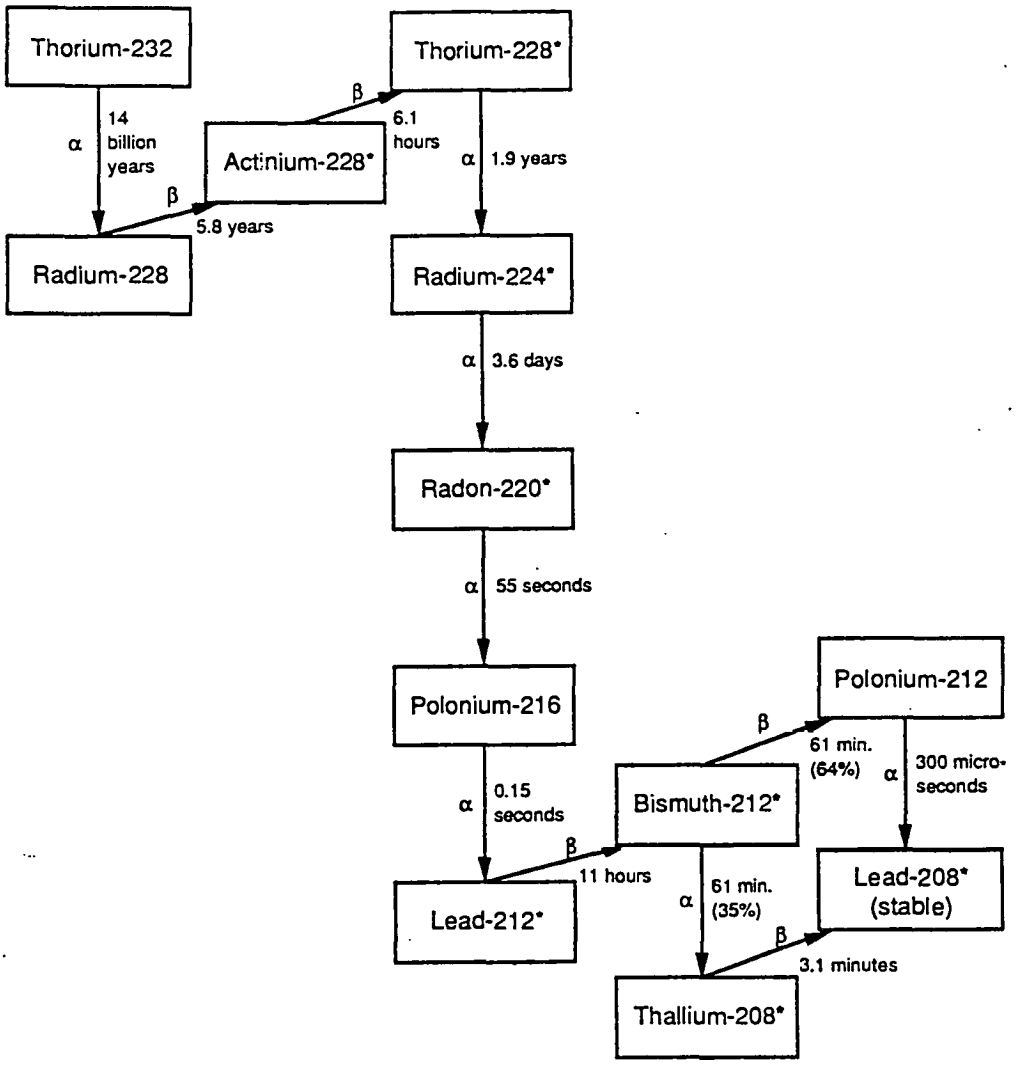
NOTES:
Only the dominant decay mode is shown.
The times shown are half-lives.
The symbols α and β indicate alpha and beta decay.
An asterisk indicates that the isotope is also a gamma emitter.

FIGURE 3-4 URANIUM-238 RADIOACTIVE DECAY SERIES



NOTES:
Only the dominant decay mode is shown.
The times shown are half-lives.
The symbols α and β indicate alpha and beta decay.
An asterisk indicates that the isotope is also a gamma emitter.

FIGURE 3-5 URANIUM-235 RADIOACTIVE DECAY SERIES



NOTES:
The times shown are half-lives.
The symbols α and β indicate alpha and beta decay.
An asterisk indicates that the isotope is also a gamma emitter.

FIGURE 3-6 THORIUM-232 RADIOACTIVE DECAY SERIES

3.5.1 Selection Criteria for Remedial Actions

Section 121 of CERCLA, as amended, identifies a strong statutory preference for remedial actions that are reliable and provide long-term protection. The primary requirements for a final remedy are that it protect human health and the environment, utilize permanent solutions, and be cost-effective. Additional selection criteria include the following:

- Preferred remedies are those in which the principal element is treatment to permanently or significantly reduce the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants.

- Where practical treatment technologies are available, off-site transport and disposal without treatment is the least preferred alternative.

- Permanent solutions and alternative treatment technologies or resource recovery technologies should be assessed and used to the maximum extent practicable.

The NCP lists nine criteria against which alternatives for a final remedy must be assessed. These criteria are: (1) overall protection of human health and the environment, (2) compliance with ARARs, (3) long-term effectiveness and permanence, (4) reduction of toxicity, mobility, or volume through treatment, (5) short-term effectiveness, (6) implementability, (7) cost, (8) state acceptance, and (9) community acceptance.

These criteria for final remedies constitute the general objectives for remedial actions at the St. Louis site. Long-term protection and permanence are the primary objectives in determining how the site materials should be managed. Cost-effectiveness and practical treatment technologies that are applicable to contaminated materials will also be considered during the development of remedial action alternatives.

3.5.2 General Response Actions and Technologies

This subsection presents a broad overview of response actions and technologies that could be implemented to achieve the objectives of remedial action at the St. Louis site, based on the current understanding of site contamination. The discussion is divided into two general categories as prescribed in the NCP: source control response actions and groundwater response actions.

Source control response actions

The objective of source control response actions is to directly control the source of contaminated materials at a waste site to minimize the potential for population exposure. A range of alternative technologies that reduce the toxicity, mobility, or volume of the hazardous substances, pollutants, or contaminants will be developed. This range will seek to include an alternative that removes or destroys the contaminants to the maximum extent feasible or that eliminates or minimizes the need for long-term management. Other alternatives will vary in the degree of treatment, the quantities and characteristics of the treatment residuals, and the untreated wastes that must be managed. One or more alternatives will be included that involve little or no treatment but provide protection of human health and the environment, primarily by preventing or controlling exposure to the contaminants through engineered controls. The alternatives will be developed and screened on the basis of effectiveness, implementability, and cost. Source control response actions that may be applicable to managing the St. Louis site include institutional controls, removal, treatment, temporary storage, and disposal.

Institutional controls can involve the use of access restrictions, such as physical barriers (e.g., fences) and ownership or deed restrictions, and/or monitoring to reduce the potential for public exposure to contaminated materials. Such controls are currently in place at SLDS, SLAPS, and HISS to limit access and use. However, these methods generally serve as a reliable means of protecting human health and the environment only when used as support for other response actions. Removal of contaminated materials can be achieved by excavation, decontamination and/or demolition, and collection technologies. Contaminated soils and sludges can be excavated with standard construction equipment. Structural surfaces can be decontaminated by a number of conventional methods (e.g., vacuuming, abrasive blasting, and scabbling), and buildings can be demolished by standard construction equipment. Finally, contaminated groundwater can be collected by various conventional methods (e.g., extraction wells and gravity drain and pumping systems). Care must be exercised in designing groundwater collection and treatment systems to avoid release or concentration of naturally occurring radioactive materials.

Treatment encompasses a wide range of chemical, physical, and biological technologies that address various types of contamination in different media. Materials associated with the St. Louis site that contain chemicals and radionuclides include soils and sludges, mixed solids and process wastes, and groundwater. Only a limited number of technologies are effective when radionuclides are present because radioactivity cannot be destroyed by treatment. Technologies that can reduce

the toxicity, mobility, and/or volume of radioactive wastes can be divided into two general categories: those that remove radioactive constituents from the waste matrix and those that change the form of the waste and/or matrix. The first category generally consists of chemical processes (although there are exceptions, such as physical separation techniques), and the second generally consists of physical processes. Biological processes are typically used to treat chemical organic wastes rather than radioactive wastes.

Chemical treatment technologies alter the nature of hazardous chemical constituents in contaminated liquids, sludges, or solids and can reduce waste toxicity, mobility, and/or volume. When radioactive components are present, a chemical extraction or leaching process can be used to remove them from the waste matrix and reduce the volume and/or mobility of the waste; the liquid leachate can then be reprocessed to isolate the radioactive components. Chemical treatment of groundwater (e.g., by precipitation and adsorption) typically follows its collection and removal, although treatment can also be conducted in situ. Soils, sludges, and solid wastes can be chemically treated either in situ (e.g., with a lixiviant wash) or following removal/excavation (e.g., in an engineered treatment system).

Physical treatment technologies can reduce the toxicity, mobility, and/or volume of waste materials, although in certain cases (e.g., sludge stabilization), the total contaminated volume may increase. Physical treatment can be used to remove contaminants from groundwater (e.g., by sedimentation, filtration, and distillation) and is typically conducted following groundwater collection and removal. Physical treatment technologies can also alter the structure of contaminated solids to facilitate stabilization and handling, and they can be implemented in situ or following excavation. Contaminated sludges can be physically treated by dewatering technologies in situ (e.g., by gravity drainage trenches and pumping) or following excavation (e.g., by vacuum filtration or drying beds). Physical treatment technologies that could be considered for contaminated soils and sludges include solids separation, nonthermal and thermal extraction, and thermal destruction.

Biological treatment technologies can alter the nature of a waste and remove contaminants (typically organics) from a waste matrix; they can be implemented in situ or following removal of contaminated materials. Biological processes are routinely employed in conventional wastewater treatment systems and can reduce waste toxicity, mobility, and/or volume. Such processes include trickling filters and surface impoundments (e.g., aerated lagoons). Organic debris and soils and sludges that contain nitrogen compounds and/or organic contaminants can also be treated by biological processes.

Containment can reduce waste mobility and the associated potential for contaminant migration and population exposure, and it can be achieved by in situ techniques. For example, groundwater can be contained by barriers to horizontal flow (e.g., slurry walls) and barriers to vertical flow (e.g., injected grout layers). Capping can reduce rain intrusion and potential leaching. The hydraulic gradient may also be controlled (e.g., by pumping systems) to limit groundwater migration. The groundwater system would require monitoring and maintenance to ensure system integrity.

When treatment technologies are used in conjunction with containment technologies for migration control, waste volume and toxicity may be reduced in addition to waste mobility. For example, contaminated groundwater can be treated by injecting reactive agents into areas of potential contamination or by using permeable treatment beds. Technologies for treating contaminated solids in a containment system include dewatering and stabilization/fixation.

3.5.3 Medium-Specific Response Objectives and Technologies

Preliminary response objectives for remedial actions at the St. Louis site have been identified for soil/sludge, surface water, groundwater, and structural materials. Potential response actions and technologies associated with source control and groundwater response actions for these objectives (see Subsection 3.5.2) are summarized in Appendix B. Additional objectives and technologies that may be appropriate for the St. Louis site will be identified and evaluated (screened) during the RI/FS-EIS process.

3.6 CONCEPTUAL REMEDIAL ACTION ALTERNATIVES

Preliminary alternatives for remedial action at the St. Louis site were developed according to the categories specified for remedial action in the current NCP, as follows:

- No action
- Alternatives for treatment or disposal at an off-site facility, as appropriate
- Alternatives that attain ARARs for protecting human health and welfare and the environment
- Alternatives that exceed ARARs

- Alternatives that do not attain ARARs but will reduce the likelihood of present or future threats from hazardous substances and will provide significant protection to human health and welfare and the environment (including an alternative that closely approaches the level of protection provided by those alternatives that attain ARARs)

Section 105 of CERCLA, as amended, required the president (who subsequently delegated this responsibility to EPA) to propose amendments to the NCP. A revision was promulgated on March 8, 1990 (EPA 1990b). The two categories of final remedial action alternatives (discussed in Subsection 3.5.2) developed in the revised NCP are:

- Source control response actions -- response actions that reduce the toxicity, mobility, or volume of the contaminants, ranging from alternatives that involve little or no treatment and rely on engineered controls to alternatives that remove or destroy the contaminants, thereby reducing the need for long-term management

- Groundwater response actions -- response actions that attain site-specific remediation levels within different restoration time periods, ranging from alternatives involving no action to alternatives that offer superior performance or implementability, fewer adverse impacts, and lower cost

A limited number of conceptual remedial action alternatives have been identified for the St. Louis site on the basis of these categories and the preliminary response objectives and technologies presented in Appendix B. (Only a general discussion of ARARs is possible at this stage of the RI/FS-EIS process; see Subsection 3.9.) These conceptual alternatives address the radioactively and chemically contaminated materials -- including soil/sludge, surface water, groundwater, and structural materials -- at the St. Louis site. The alternatives are:

- Alternative 1: No action
- Alternative 2: On-site disposal
- Alternative 3: Off-site (including out of state) disposal
- Alternative 4: On-site treatment with on-site disposal
- Alternative 5: On-site treatment with off-site disposal
- Alternative 6: Off-site (including out of state) treatment with off-site disposal

These alternatives are briefly described in Subsections 3.6.1 through 3.6.6 and represent basic combinations of potential response actions. Options may be identified within certain of the action alternatives -- i.e., Alternatives 2 through 6 -- to incorporate appropriate elements of other alternatives as the RI/FS-EIS process develops. For example, Alternative 4 might be varied to incorporate an element of Alternative 6 (off-site treatment and/or disposal) on a limited basis if a licensed facility were available for certain materials. Similarly, Alternative 5 could incorporate the focus of Alternative 2 (on-site containment for disposal) on a limited basis (e.g., if excavation of a small area of contaminated soil located beneath a paved surface would create a greater risk to workers than if it were contained in place and monitored/maintained for the long term).

3.6.1 No Action

The no-action alternative is included pursuant to the requirements of NEPA and CERCLA to provide a baseline for comparison with other alternatives and to assess the impacts on human health and the environment from current and projected conditions at the St. Louis site. If this option were selected, no reduction would occur in the toxicity, mobility, or volume of contaminated materials at the site. Potential exposure to contaminants would probably continue for the short term at current levels; over time, long-term exposure would likely increase in terms of both levels of exposure and size of potentially affected population.

3.6.2 On-Site Disposal

On-site disposal would reduce waste mobility and would require monitoring and maintenance, permanent access restrictions, and other institutional controls (e.g., management of a buffer zone between the facility and surrounding areas). On-site disposal could involve in situ containment (e.g., with caps and slurry walls) and/or construction of an engineered facility to isolate materials following their removal (e.g., via building demolition or soil excavation). Most importantly, this alternative would involve a determination of site suitability -- including site capacity and consideration of its location in an urbanized area -- prior to any waste removal or design and construction activities.

Additional information may be required in the future if, for example, SLAPS is identified as the preferred permanent disposal site. Such information would include the height of the stratigraphically lower aquifer and data on groundwater flow, direction, and gradient. Additionally, treatment technologies applicable to radioactively contaminated materials at the site would have to be identified and waste treatability studies initiated, as appropriate, to evaluate the feasibility and effectiveness of the technologies.

Several potential remedial action technologies may require bench-scale or pilot-scale treatability studies. The technologies that may warrant such testing for use at the FUSRAP properties in the St. Louis area include:

- Building decontamination - On-site testing of various decontamination methods may be necessary to determine their effectiveness for specific application to SLDS. This information is needed to determine both feasibility and cost.

- Solids separation - Historically, separation of soil and radioactive contaminants has been ineffective and has also been highly dependent on physical characteristics of the soil and the radionuclides of concern. Bench-scale testing may be needed to determine the usefulness of this treatment approach for soils and sediments.

- In situ tests - Technologies to reduce the mobility of hazardous constituents of the wastes may need to be tested to determine applicability to the FUSRAP properties in the St. Louis area. These may include surface spraying for contaminated buildings and equipment, cutoff walls and grouting/stabilization for groundwater protection, and vitrification for contaminated soils and sediments.

3.9 PRELIMINARY IDENTIFICATION OF REGULATORY REQUIREMENTS

Remedial action activities at the St. Louis site will be conducted in accordance with DOE orders and all pertinent ARARs for protecting human health and the environment. Specific requirements of certain orders are presented in Appendix E. The requirements of DOE Order 5400.5, for radiation protection of the public and the environment, are considered pertinent to the proposed action because residual soil and surface radionuclide contamination at the St. Louis site has been found to exceed the requirements specified in this order. Major ARARs

4.0 WORK PLAN RATIONALE

4.1 OVERVIEW OF DATA OBJECTIVES AND ASSOCIATED ACTIVITIES

A major element of the RI/FS-EIS process is obtaining sufficient site-specific information and data to support assessment of site risks and evaluation of remedial action alternatives. Collection and documentation of data are conducted during the RI phase; analysis of alternatives is conducted in the FS-EIS phase. The level of detail and the quality of data required vary, based on the intended uses of the data.

Work at the St. Louis site needed to support the RI/FS is complete, and associated data objectives have been met. Investigation objectives and field activities associated with each area of the St. Louis site are summarized in Table 4-1. Results from the data acquisition activities will be documented in an RI report to support FS activities for the site.

4.2 QUALITY ASSURANCE OBJECTIVES FOR REMEDIAL INVESTIGATION

This subsection provides an overview of the quality assurance (QA) objectives that were considered during the RI. In general, QA objectives were divided into three major categories: analytical requirements, data QA requirements, and sample handling requirements.

4.2.1 Analytical Requirements

Selection of analytical requirements was based on two primary factors: that the method detection limit for the method selected was adequate to identify potential contaminants for which DOE is responsible, and that the method selected was a standard method. The analytical techniques selected for analysis of chemical, radiological, and engineering/geochemical parameters are given in Tables 4-2 through 4-4. In cases where the selected analytical technique could not be used or had to be modified, the appropriate section of the RI report will note the change and discuss any impacts on the data.

TABLE 4-1

SUMMARY OF DATA OBJECTIVES AND FIELD ACTIVITIES FOR THE ST. LOUIS SITE

Area/ Investigation Objective	Chemical Characterization	Radiological Characterization	Geological/Physical Characterization	Status
SLDS				
Determine nature and extent of contamination; determine presence of RCRA-hazardous wastes.	Phase I - Analyzed soil samples from 59 boreholes for metals, VOCs, semivolatiles, and RCRA characteristics. Phase II - Sampled and analyzed soil from 51 boreholes for chemical constituents to further define boundaries of chemical contamination by testing for metals and RCRA characteristics.	ORNL radiological survey. BNI characterization, which included walkover gamma scans conducted on the city property and portions of SLDS, gamma logging in boreholes to identify areas of elevated radioactivity in subsurface soils. 297 surface samples collected and 218 boreholes sampled; analyzed for uranium-238, radium-226, thorium-232, and thorium-230.	BNI installed 10 geologic boreholes (9 of which were completed as monitoring wells).	Need radiological surveys of sumps/drains and building interiors.
Investigate potential migration of contaminants from soil into groundwater.	BNI analysis of groundwater from 8 wells (4 deep, 4 shallow) for various chemical parameters including VOCs, semivolatiles, pesticides, PCBs, metals, pH, specific conductance, TOX, and TOC.	BNI analysis from 9 wells quarterly for uranium-238, radium-226, thorium-230, and thorium-232.		Complete

TABLE 4-1
(continued)

Area/ Investigation Objective	Chemical Characterization	Radiological Characterization	Geological/Physical Characterization	Status
SLAPS				
Determine extent and nature of surface and subsurface radioactive and chemical contamination including RCRA wastes.	BNI limited characterization to provide information regarding the nature and potential presence of hazardous wastes in soil. BNI characterization included analysis for metals, mobile ions, VOCs, semivolatiles, and RCRA characteristics. 30 boreholes sampled and 109 samples analyzed.	ORNL radiological investigation of drainage ditches designated for remedial action. BNI radiological survey of ditches. BNI radiological characterization of the property, which included walkover gamma scans, near-surface gamma radiation levels, gamma radiation exposure rates, downhole gamma logging to identify areas of elevated radioactivity in subsurface soils. Analyzed samples from 102 boreholes for uranium-238, radium-226, thorium-232, and thorium-230 in some cases.	18 geologic boreholes (backfilled with grout).	Complete
Determine baseline conditions of and monitor changes in groundwater and surface water, radon concentrations, and gamma radiation levels to determine whether detrimental leakage of contaminants is occurring.	BNI environmental monitoring: quarterly analysis of groundwater for pH, specific conductance, TOC, TOX, and metals (1988-1989). BNI analysis for metals in groundwater for 5 quarters.	BNI environmental monitoring includes groundwater, sediment, and surface water for uranium, radium-226, thorium-232, thorium-230, radon, and external gamma radiation levels. 12 radon monitoring locations.		Ongoing
			10 monitoring wells for EM program.	Complete
			Canvass area wells.	Complete

TABLE 4-1
(continued)

Area/ Investigation Objective	Chemical Characterization	Radiological Characterization	Geological/Physical Characterization	Status
HISS				
Determine the nature and extent of surface and subsurface contamination; identify indicator contaminants; determine presence of RCRA-hazardous wastes.	BNI characterization included analysis for RCRA waste characteristics, mobile ions, metals, VOCs, and semivolatiles. 15 samples analyzed (3 random boreholes and 3 biased boreholes).	NRC radiological survey. ORNL radiological characterization. ORAU radiological characterization of storage pile at HISS. ORNL detailed radiological survey of north and south shoulders of Latty Avenue. BNI radiological characterization included walkover surveys, near-surface gamma measurements, gamma exposure rates, downhole gamma logging in all boreholes, continuous sampling at 1-ft increments in each borehole, and analysis for uranium-238, radium-226, and thorium-232. Selected samples from 36 boreholes analyzed for thorium-230.		Complete
Determine baseline conditions of and monitor changes in groundwater and surface water, radon concentrations, and gamma radiation levels to determine whether leakage of contaminants is occurring.	BNI environmental monitoring: quarterly analysis of groundwater for pH, specific conductance, TOC, TOX, and metals (for 5 quarters during 1988 and 1989).	BNI environmental monitoring includes groundwater, sediment, and surface water for uranium, radium-226, thorium-230, radon, and external gamma radiation levels. 13 radon monitoring locations.	10 monitoring wells.	Ongoing
			Canvass area wells.	Complete

TABLE 4-1
(continued)

Area/ Investigation Objective	Chemical Characterization	Radiological Characterization	Geological/Physical Characterization	Status
FUTURA COATINGS, INC.				
Determine nature and extent of surface and subsurface contamination; identify indicator contaminants; determine extent of contamination inside buildings.	BNI characterization included analysis for RCRA waste characteristics, mobile ions, metals, VOCs, and semivolatiles. 3 random boreholes and 3 biased boreholes.	ORNL radiological characterization. BNI characterization. Phase I - Environmental monitoring inside buildings for radon and gamma levels and gross alpha concentrations. Phase II - Included walkover surveys, near-surface gamma measurements, gamma exposure rates, downhole gamma logging allowing for selected samples to be analyzed for uranium-238, radium-226, thorium-232, and thorium-230. 48 exterior radiological boreholes were drilled. All samples from 10 boreholes beneath the building were analyzed.		Complete

TABLE 4-1
(continued)

Area/ Investigation Objective	Chemical Characterization	Radiological Characterization	Geological/Physical Characterization	Status
VICINITY PROPERTIES				
Ball field (SLAPS)				
Determine nature and extent of contamination; identify indicator parameters; determine presence of RCRA-hazardous wastes; determine the boundaries of contamination.	BNI chemical characterization. Samples from 11 boreholes analyzed for mobile ions, VOCs, semivolatiles, RCRA characteristics, pesticides/PCBs, and metals.	BNI radiological characterization included near-surface gamma measurements and downhole gamma logging and analysis of 680 soil samples (some composites) for uranium-238, radium-226, thorium-232, and/or thorium-230.	27 monitoring wells.	Complete
Ditches north and south of SLAPS				
Determine the nature and extent of radioactive contamination.	None	BNI radiological characterization included near-surface gamma measurements, downhole gamma logging, and analysis of surface and subsurface samples from 87 radiological boreholes for uranium-238, radium-226, thorium-232, and/or thorium-230.		Complete
St. Louis Airport Authority property				
Determine the nature and extent of radioactive contamination.	None	BNI radiological characterization included near-surface gamma measurements, downhole gamma logging, and analysis of soil samples from 66 radiological boreholes for uranium-238, radium-226, thorium-232, and/or thorium-230.		Complete

TABLE 4-1
(continued)

Area/ Investigation Objective	Chemical Characterization	Radiological Characterization	Geological/Physical Characterization	Status
Coldwater Creek				
Determine the boundaries and extent of radioactive contamination and determine whether chemical contamination exists along the creek.	Analyzed 4 samples for metals, mobile ions, volatiles, and semivolatiles	BNI - radiological characterization of ditches and portions of Coldwater Creek. BNI radiological characterization of Coldwater Creek from SLAPS to HISS included drilling 519 radiological boreholes, performing a walkover gamma survey, downhole gamma logging, and sediment sampling. Analysis was conducted for uranium-238, radium-226, thorium-232, and/or thorium-230. Analyzed 110 samples for all radionuclides of interest extending 1.5 m. past previous survey. Analyzed 100 samples for all radionuclides of interest extending 4.8 mi from Bruce Drive in Florissant to Old Halls Ferry Road. Analyzed 125 samples for all radionuclides of interest from areas on either side of Coldwater Creek extending to the Missouri River.		Complete

TABLE 4-1
(continued)

Area/ Investigation Objective	Chemical Characterization	Radiological Characterization	Geological/Physical Characterization	Status
Coldwater Creek vicinity properties				
Determine extent and boundaries of radioactive contamination.	None	BNI radiological characterization included walkover gamma scans and downhole gamma logging. Analyzed 120 samples for uranium-238, radium-226, thorium-232 and thorium-230.		Complete
Haul roads vicinity properties				
Determine extent and boundaries of radioactive contamination.	None	ORNL radiological survey. BNI analyzed 3,000 soil samples for thorium-230. Further characterization of 13 properties involved analyzing 240 soil samples (to a depth of 3 ft) for uranium-238, radium-226, thorium-232, and thorium-230.		Complete
Norfolk and Western Railroad Property				
Determine extent and boundaries of radioactive contamination.	BNI sampled and analyzed soil from 4 boreholes for chemical constituents to further demonstrate the lack of chemical contamination on these properties by testing for metals, VOCs, BNAEs, and RCRA characteristics.	BNI characterization included gamma exposure rates, downhole gamma logging, and analysis of soil samples from 200 radiological boreholes for uranium-238, radium-226, thorium-232, and/or thorium-230.		Complete

TABLE 4-1
(continued)

Area/ Investigation Objective	Chemical Characterization	Radiological Characterization	Geological/Physical Characterization	Status
Railroad property adjacent to Coldwater Creek				
Determine extent and boundaries of radioactive contamination.	None	Radiological characterization included analyzing 120 samples from 30 boreholes for uranium-238, radium-226, thorium-232, and thorium-230.		Complete
Banshee Road				
Determine extent and boundaries of radioactive contamination.	None	BNI radiological characterization included downhole gamma logging in 47 boreholes. Analyses for uranium-238, radium-226, thorium-232, and/or thorium-230 were conducted for soil samples from 48 boreholes.		Complete
SLDS vicinity properties				
Determine nature and extent of radioactive contamination.	None	BNI preliminary radiological characterization included analyses of soil samples for uranium-238, radium-226, thorium-232, and thorium-230.		Complete

TABLE 4-1
(continued)

Area/ Investigation Objective	Chemical Characterization	Radiological Characterization	Geological/Physical Characterization	Status
Hanley Road at intersection with Latty Avenue				
Determine extent and boundaries of radioactive contamination.	None	Further radiological characterization included analysis of soil samples from 12 boreholes for uranium-238, radium-226, thorium-232, and thorium-230.		Complete
Pathway from SLDS to SLAPS				
Determine whether radioactive contamination exists on possible transportation routes.	None	Conducted ORNL mobile gamma scan from SLDS to SLAPS.		Complete

TABLE 4-2

METHODS FOR ANALYSIS OF WATER

Parameter	Analytical Technique	Method Detection Limit[a]
Metals[b,c,d]	ICPAES[c]: EPA 200-7-CLP-M	0.3 - 7.4 µg/L[f]
	As[c]: EPA 206.2-CLP-M	0.001 µg/L
	Tl[c]: EPA 279.2-CLP-M	0.001 µg/L
	Se[c]: EPA 270.2-CLP-M	0.002 µg/L
	Pb[c]: EPA 239.2-CLP-M	0.001 µg/L
	All others: U.S. EPA[c]	5-5000 µg/L[f]
Volatile organics	EPA method 8240 (SW 846)	5-10 µg/L[f]
Semivolatile organics	EPA method 8270 (SW 846)	10-50 µg/L[f]
Pesticides/ polychlorinated biphenyls	EPA method 8080 (SW 846)	0.05-1.0 µg/L[f]
pH	Electrometric: EPA 150.1	--
Total organic carbon	EPA 415.1	1 mg/L
Specific conductance	Electrometric: EPA 120.1	0.1 mg/L
Fluoride	Ion-selective electrode: EPA 340.2	0.1 mg/L
Nitrate	Ion chromatography: EPA 353.1	0.14 mg/L
Sulfate	Colorimetric: EPA 375.1	10 mg/L
Total organic halides	EPA method 9020 (SW 846)	--
Thorium	Alpha spectrometry EML-Th-03 (modified)	0.5 pCi/L
Radium	Alpha spectrometry of radon emanation: EPA 903.1	0.1 pCi/L
Uranium	Fluorimetry EML-U-03	5 µg/L

[a]Published method detection limits. The laboratory attempts to maintain the published method detection limits; however, matrix interference will raise the detection limits.

[b]Include aluminum, antimony, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lanthanides, lithium, magnesium, manganese, molybdenum, nickel, potassium, silver, sodium, vanadium, and zinc. Arsenic, selenium, thallium, and lead analyses are by furnace atomic absorption.

[c]Samples will be prepared for analyses in accordance with procedures outlined in Exhibit D of the CLP-SOW for inorganics analyses (EPA 1988b).

[d]For boron, lithium, molybdenum, and lanthanides, which are not standard CLP analyses, the following was done: interference standards were prepared and a calibration curve determined, initial calibration verification (ICV) and calibration curve verification (CCV) standards were prepared at a midrange concentration, and a laboratory control sample was prepared by digesting the ICV standard.

[e]ICPAES - Inductively coupled plasma atomic emission spectrophotometry.

[f]Range of detection limits.

TABLE 4-3

METHODS FOR ANALYSIS OF SOIL

Parameter	Analytical Technique	EPA Method No.
Metals[a,b]	ICPAES[c]	200.7-CLP-M
Sulfate	Colorimetric	9035
Nitrate	Kjeldahl, distillation, titration	351
Fluoride	Distillation, ISE	340.1
Mercury	Cold vapor atomic absorption	--
Volatile organics	GC/Hall/PID[d]	Modified[e] 8010/8015
Base/neutral and acid extractable organics	GC/FID and GC/MS[f]	Modified[g] 8250
Extraction procedure toxicity	Various	1310
Corrosivity	Electrometric	111.0
Ignitability	--	1010
Reactivity-sulfide	Titration	9030
Reactivity-cyanide	Titration	9010
Isotopic uranium	Radiochemical	U-04[h]
Isotopic radium	Radiochemical	Ra-07[h]
Isotopic thorium	Radiochemical	Th-03[i]
Uranium-238	Gamma spectrometry	C-02[h]
Radium-226	Gamma spectrometry	C-02[h]
Thorium-232	Gamma spectrometry	C-02[h]

TABLE 4-3
(continued)

[a]Includes aluminum, antimony, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lanthanides, lithium, magnesium, manganese, molybdenum, nickel, potassium, silver, sodium, vanadium, and zinc.

[b]Soil samples will be prepared for analyses in accordance with procedures outlined in Exhibit D of the CLP-SOW for inorganic analysis (EPA 1988b).

[c]ICPAES - Inductively coupled plasma atomic emission spectrophotometry.

[d]GC/Hall/PID - Gas chromatography/Hall detector/pressurized ionization detector.

[e]Modification substitutes the use of GC/Hall/PID for the GC/MS.

[f]GC/FID/MS - gas chromatography/flame ionization detector/mass spectrometry.

[g]Modified to include use of GC/FID instead of GC/MS.

[h]TMA/E utilizes laboratory procedure developed by Environmental Measurements Laboratory-300 (EML-300).

[i]Modified by Environmental Measurements Laboratory procedure to accommodate the matrix.

TABLE 4-4

ENGINEERING/GEOTECHNICAL TEST METHODS[a]

Test	Method[b,c]
Gradation/hydrometer	ASTM D422
Cation exchange capacity	ASTM STP-805
Distribution coefficient	ASTM D4319
Atterberg limits	ASTM D4318
Unit weight (wet/dry)	DA EM 1110-2-1906
Moisture content	ASTM D2216
Centrifuge moisture equivalent	ASTM D425
Specific gravity	ASTM D854

[a]All analyses meet industry standard detection limits.

[b]ASTM - American Society for Testing and Materials.

[c]DA EM - Department of Army Engineer Manual.

Analytical methods and equipment were also selected based on the quality of data required for the RI. The EPA guidance on data quality objectives (DQOs) establishes five levels of quality applicable to various chemical data gathering activities during the RI/FS process (Figure 4-1) (EPA 1987b). For the St. Louis site RI, the radiological and chemical data collected with field instruments correspond to analytical level I. The chemical data obtained from samples analyzed at the fixed-base laboratory correspond to level III. EPA does not currently have defined DQOs for radiological analyses; however, the quality of radiological analyses conducted by the fixed-base laboratory corresponds to level III.

4.2.2 Data Quality Assurance Requirements

The data QA requirements used to guide sample collection and data use were that: (1) the accuracy of the data was acceptable for guiding future remedial action efforts, (2) the precision of the data provided a high level of confidence in the analytical methods being used, (3) the data collected were complete with respect to the planned activities, (4) the data represented the medium/environment sampled, and (5) the data sets received were comparable.

Accuracy

Accuracy is the degree of agreement between a measurement and an accepted reference, or true value, of the analytical method used. Accuracy is normally established through analysis of spiked samples and standard reference materials (SRMs). Spiked soil samples could not be obtained for the radiological analyses, but accuracy was determined by analyzing SRMs of known activity. In general, an SRM sample was analyzed with each batch of 20 samples or fewer. The accuracy of the chemical analyses was evaluated with the use of method spikes (prepared in the laboratory), matrix spikes (field samples spiked in the laboratory), and SRMs. The method spikes and SRMs were analyzed with each batch of 20 samples or fewer. The matrix spikes were also analyzed with each batch of 20 samples or fewer when sufficient volume of sample was available.

The accuracy of each set of measurements will be discussed in the RI report.

Precision

Precision is the measure of mutual agreement among individual measurements of the same property under similar conditions. Precision is normally determined from the results of field

DATA USES	ANALYTICAL LEVEL	TYPE OF ANALYSIS	LIMITATIONS	DATA QUALITY
• SITE CHARACTERIZATION • MONITORING DURING IMPLEMENTATION	LEVEL I	• TOTAL ORGANIC/INORGANIC VAPOR DETECTION USING PORTABLE INSTRUMENTS • FIELD TEST KITS	• INSTRUMENTS RESPOND TO NATURALLY OCCURRING COMPOUNDS	• IF INSTRUMENTS CALIBRATED AND DATA INTERPRETED CORRECTLY, CAN PROVIDE INDICATION OF CONTAMINATION
• SITE CHARACTERIZATION • EVALUATION OF ALTERNATIVES • ENGINEERING DESIGN • MONITORING DURING IMPLEMENTATION	LEVEL II	• VARIETY OF ORGANICS BY GC/MS; INORGANICS BY AA, XRF	• TENTATIVE IDENTIFICATION ANALYTE-SPECIFIC • TECHNIQUES/INSTRUMENTS LIMITED MOSTLY TO VOLATILES, METALS • DETECTION LIMITS VARY FROM LOW ppm TO LOW ppb	• DEPENDENT ON QA/QC STEPS EMPLOYED • DATA TYPICALLY REPORTED IN CONCENTRATION RANGES
• RISK ASSESSMENT • PRP DETERMINATION • SITE CHARACTERIZATION • EVALUATION OF ALTERNATIVES • ENGINEERING DESIGN • MONITORING DURING IMPLEMENTATION	LEVEL III	• ORGANICS/INORGANICS USING EPA PROCEDURES OTHER THAN CLP CAN BE ANALYTE-SPECIFIC • RCRA CHARACTERISTICS TESTS	• TENTATIVE IDENTIFICATION IN SOME CASES • CAN PROVIDE DATA OF SAME QUALITY AS LEVEL IV	• DETECTION LIMITS SIMILAR TO CLP • LESS RIGOROUS QA/QC
• RISK ASSESSMENT • PRP DETERMINATION • EVALUATION OF ALTERNATIVES • ENGINEERING DESIGN	LEVEL IV	• TCL ORGANICS/INORGANICS BY GC/MS, AA, ICP • LOW ppb DETECTION LIMIT	• TENTATIVE IDENTIFICATION OF NON-TCL PARAMETERS • SOME TIME MAY BE REQUIRED FOR VALIDATION OF PACKAGES	• GOAL IS TO OBTAIN DATA OF KNOWN QUALITY • RIGOROUS QA/QC
• RISK ASSESSMENT • PRP DETERMINATION	LEVEL V	• NONCONVENTIONAL PARAMETERS • MODIFICATION OF EXISTING METHODS • APPENDIX 8 PARAMETERS (EPA)	• MAY REQUIRE METHOD DEVELOPMENT/MODIFICATION • MECHANISM TO OBTAIN SERVICES REQUIRES SPECIAL LEAD TIME • METHOD-SPECIFIC DETECTION LIMITS	• METHOD-SPECIFIC

AA = ATOMIC ABSORPTION
CLP = CONTRACT LABORATORY PROGRAM
EPA = ENVIRONMENTAL PROTECTION AGENCY
GC/MS = GAS CHROMATOGRAPHY/ MASS SPECTROMETRY
ICP = INDUCTIVELY COUPLED PLASMA
ppb = PARTS PER BILLION
ppm = PARTS PER MILLION
PRP = POTENTIALLY RESPONSIBLE PARTY
QA/QC = QUALITY ASSURANCE/QUALITY CONTROL
RCRA = RESOURCE CONSERVATION AND RECOVERY ACT
TCL = TARGET COMPOUND LIST
XRF = X-RAY FLUORESCENT ANALYZER

SOURCE: ENVIRONMENTAL PROTECTION AGENCY, *Data Quality Objectives for Remedial Response Activities, Development Process*, EPA/540/6-87/003, WASHINGTON, D.C., MARCH 1987.

FIGURE 4-1 SUMMARY OF ANALYTICAL LEVELS APPROPRIATE TO DATA USES

duplicates (a duplicate sample collected under the same conditions and in the same location as a previous sample), laboratory duplicates (a separate, laboratory-prepared aliquot of a sample received for analysis), and split samples (a separate, field-prepared aliquot of a sample).

The precision of the radiological analyses for gamma activity was determined by reanalyzing 1 sample in every batch of 20 or fewer. This technique was used because the measurement is noninvasive and the sample is not disturbed between measurements. The precision of thorium-230 measurements was determined through the use of laboratory duplicates. A laboratory duplicate was analyzed for each batch of 20 samples or fewer.

The precision of the chemical analyses was determined through the use of field duplicates, laboratory duplicates, and split samples. In general, the measurements were conducted on 1 sample from each batch of 20 samples or fewer. In some cases, however, a sufficient volume of sample could not be recovered to provide the required duplicate and split samples.

The precision of each set of measurements will be discussed in the RI report. Also included is a discussion of the usefulness of the results for those cases where the planned quality control (QC) samples could not be collected.

Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount expected to be obtained under correct, normal conditions. In general, each data set collected contained sufficient information to fulfill the data gaps identified for the area under investigation. A detailed discussion of the completeness of each data set will be included in the RI report.

Representativeness

Representativeness is the degree to which the data accurately and precisely represent the medium/environment where the samples were obtained. For all sampling events, sampling locations were selected using either random or systematic strategies to ensure that the vertical and horizontal boundaries of the waste were identified and that the characteristics of the waste were known.

Comparability

Comparability is the degree to which the data generated during one portion of the RI can be compared with data generated during another. Comparability was ensured through the use of EPA-designated reference or equivalent sampling procedures and analytical methods. Additionally, compatible units were selected for all chemical and radiological results.

4.2.3 Sample Handling

Sample handling includes tracking the collection, preservation, shipment, and documentation of a sample. The QA/QC objectives for the sample collection, packaging, and shipment portion of the field activities were to verify that decontamination, packaging, and shipping are not introducing variables into the sampling chain that could make the validity of the samples questionable. To fulfill these QA objectives, trip, field, and method blank QC samples were used. These samples were typically analyzed with each batch of samples shipped. Results of these measurements will be discussed in the RI report.

Table 4-5 summarizes the types of samples collected and the analyses performed on each type. Table 4-6 provides information on preservation methods, holding times, and types of containers used for the applicable chemical parameters.

Records of samples collected, measurements taken, and observations of events and conditions that could affect data quality were made during field activities. The records provided sufficient data and observations to enable participants to reconstruct events that occurred during that data collection process, help qualify data, and refresh the memories of field personnel. All original data collected in the field are considered permanent records.

4.2.4 Sample Custody

Identification and documentation of the possession history of a sample from collection through analysis and ultimate disposition was important to ensure that the validity of the sample has not been compromised. Chain-of-custody procedures provide for sample labeling and tracking reports that contain unique sample identification, documentation of specific reagents or supplies that became an integral part of the sample, sample preservation methods, and sample custody logs.

TABLE 4-5

SAMPLE TYPES AND ANALYTICAL PARAMETERS

Parameter	Medium			
	Soil	Ground-water	Surface Water	Sediment
Radiological				
Thorium-230	0	0	0	0
Thorium-232	0	0	0	0
Radium-226	0	0	0	0
Uranium-238	0	0	0	0
Metals[a]				
ICPAES[b]	0	0	0	0
TCLP or EP tox[c]	0	--	--	--
Mobile Ions				
Fluoride	0	0	0	0
Nitrate	0	0	0	0
Sulfate	0	--	--	--
Organics				
Volatile organics	0	0	0	0
Semivolatile organics	0	0	0	0
TCLP or EP tox	0	--	--	--
Engineering and Geotechnical				
Gradation/ hydrometer	0	--	--	0
Cation exchange capacity	0	--	--	0
Distribution coefficient	0	--	--	0
Atterberg limits	0	--	--	--
Specific gravity	0	--	--	--
Unit weight (wet/dry)	0	--	--	--
Moisture content	0	--	--	--
Centrifugal moisture equivalent	0	--	--	--

TABLE 4-5
(continued)

Parameter	Medium: Soil	Ground-water	Surface Water	Sediment
Miscellaneous Indicators				
Temperature	--	0	0	--
pH	0	0	0	--
Specific conductance	--	0	0	--
Dissolved oxygen	--	0	0	--

0 - Analysis conducted.

-- - Analysis not performed.

NOTE: For characterization purposes, radon was monitored within buildings and at property perimeters. At SLAPS and HISS, it is monitored quarterly at the property fencelines.

[a]Includes aluminum, antimony, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc. Arsenic and lead analyses are by furnace atomic absorption.

[b]ICPAES - Inductively coupled plasma atomic emission spectrophotometry.

[c]TCLP - Toxicity characteristic leaching procedure; EP tox - extraction procedure toxicity.

TABLE 4-6

PRESERVATION METHODS, HOLDING TIMES, AND CONTAINERS FOR CHEMICAL SAMPLES

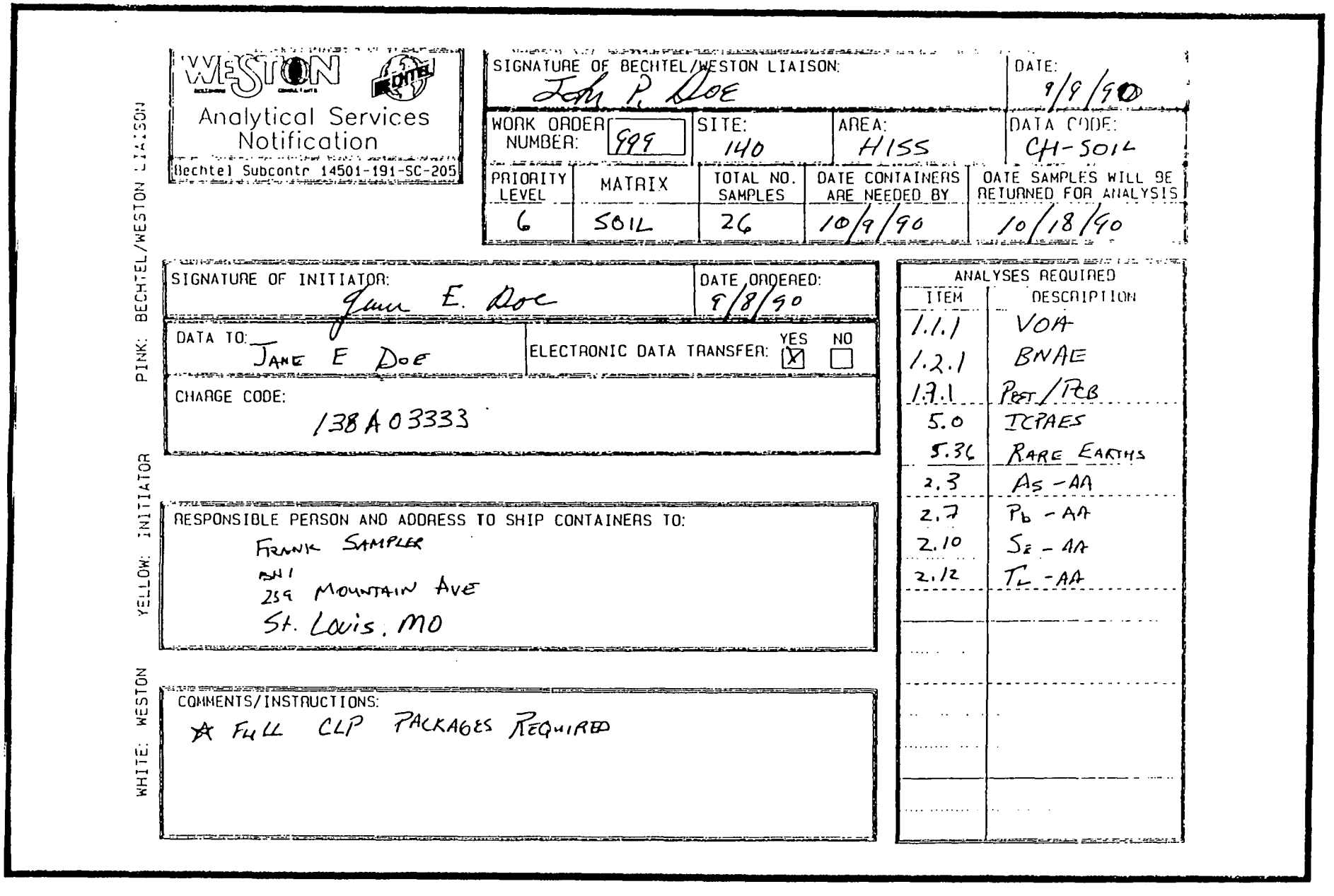
Parameter	Sample Matrix	Preservation Method	Maximum Holding Time	Type of Container
Volatile organics	Water/sediment/soil	Cool, 4°C Cool, 4°C	5 days 10 days	(2) 40-ml glass vial (2) 120-ml wide-mouth glass vial with Teflon liner
Base/neutral and acid extractable organics	Water	Cool, 4°C	5 days until extraction, then 40 days until analysis	(1) 8-oz wide-mouth glass bottle with Teflon cap liner
	Sediment/ soil	Cool, 4°C	10 days until extraction, then 40 days until analysis	
Metals	Water	Nitric acid to pH <2	6 months	(1) 1-L polyethylene bottle
	Sediment/ soil	Cool, 4°C	6 months	(1) 8-oz wide-mouth glass bottle with Teflon cap liner
Mobile Ions				
Cyanides	Water	NaOH to pH >12 Cool, 4°C	14 days	(1) 1-L polyethylene bottle
	Sediment/ soil	Cool, 4°C	14 days	1-L polyethylene bottle (included in the metals sample)
Nitrate	Water	H_2SO_4 to pH <2 Cool, 4°C	14 days	1-L polyethylene bottle

Chemical samples

Prior to sampling, a staff member in the BNI Oak Ridge office obtained a copy of the analytical services notification form and completed the form with the assistance of the BNI/RFW liaison. An example of the completed form is shown in Figure 4-2. This form was checked by the BNI/RFW liaison to ensure completeness before submittal to the laboratory. Upon receipt of the form, the laboratory determined the number of sample containers needed and shipped them to the site. A copy of the completed form was sent to field sampling personnel. Generic information was copied to the request form for analytical services (Figure 4-3), including the analyses requested to ensure that the correct sample analyses were requested by field personnel. This process also ensured that the correct sample containers (containing all required preservatives) were provided to the field sampling team. Finally, the process provided early notification to RFW of upcoming sampling, thereby allowing them to stage samples appropriately.

Each chemical sample had a unique identification, and a chain-of-custody record accompanied each sample submitted for analysis. Samples for chemical analysis were handled in accordance with the EPA manual User's Guide to the Contract Laboratory Program (EPA 1986). Samples were traceable from the time they were collected until they, or their derived data, were documented in a report. The final custody documentation procedure was used in conjunction with RFW sample documentation for all samples processed through RFW to maintain a record of sample collection, transfer between personnel, and shipment and receipt by the laboratory. RFW used a request form for analytical services that was completed for each sample type. Each time samples were transferred to another custodian, the signature(s) of the person(s) relinquishing the sample and receiving the sample, the reason for relinquishing the sample, and the time and date were documented. A sample was considered to be in a particular individual's custody if it was (1) in that person's physical possession, (2) in view of the person who took possession or secured by that person so that no one could tamper with it, or (3) in a secure area.

A sample custodian designated by the laboratory accepted custody of the samples and verified that the information on the labels matched that on the request for analytical services. The custodian then entered the information from the sample label into the laboratory sample tracking system. Samples were distributed to the appropriate analyst, who was responsible for them until they were exhausted or returned to the custodian. After all analyses were completed, the samples (if radioactively contaminated) were returned to the site or to TMA/E for storage. Nonradioactively contaminated samples were sent for commercial disposal.



WESTON / BECHTEL

Analytical Services Notification

Bechtel Subcontr 14501-191-SC-205

SIGNATURE OF BECHTEL/WESTON LIAISON: John P. Doe

DATE: 9/9/90

WORK ORDER NUMBER:	SITE:	AREA:	DATA CODE:
999	140	H155	CH-SOIL

PRIORITY LEVEL	MATRIX	TOTAL NO. SAMPLES	DATE CONTAINERS ARE NEEDED BY	DATE SAMPLES WILL BE RETURNED FOR ANALYSIS
6	SOIL	26	10/9/90	10/18/90

SIGNATURE OF INITIATOR: Jane E. Doe

DATE ORDERED: 9/8/90

DATA TO: JANE E DOE

ELECTRONIC DATA TRANSFER: YES [X] NO [ ]

CHARGE CODE: 138A03333

RESPONSIBLE PERSON AND ADDRESS TO SHIP CONTAINERS TO:

FRANK SAMPLER
ANL
259 MOUNTAIN AVE
ST. LOUIS, MO

COMMENTS/INSTRUCTIONS:

* FULL CLP PACKAGES REQUIRED

ANALYSES REQUIRED

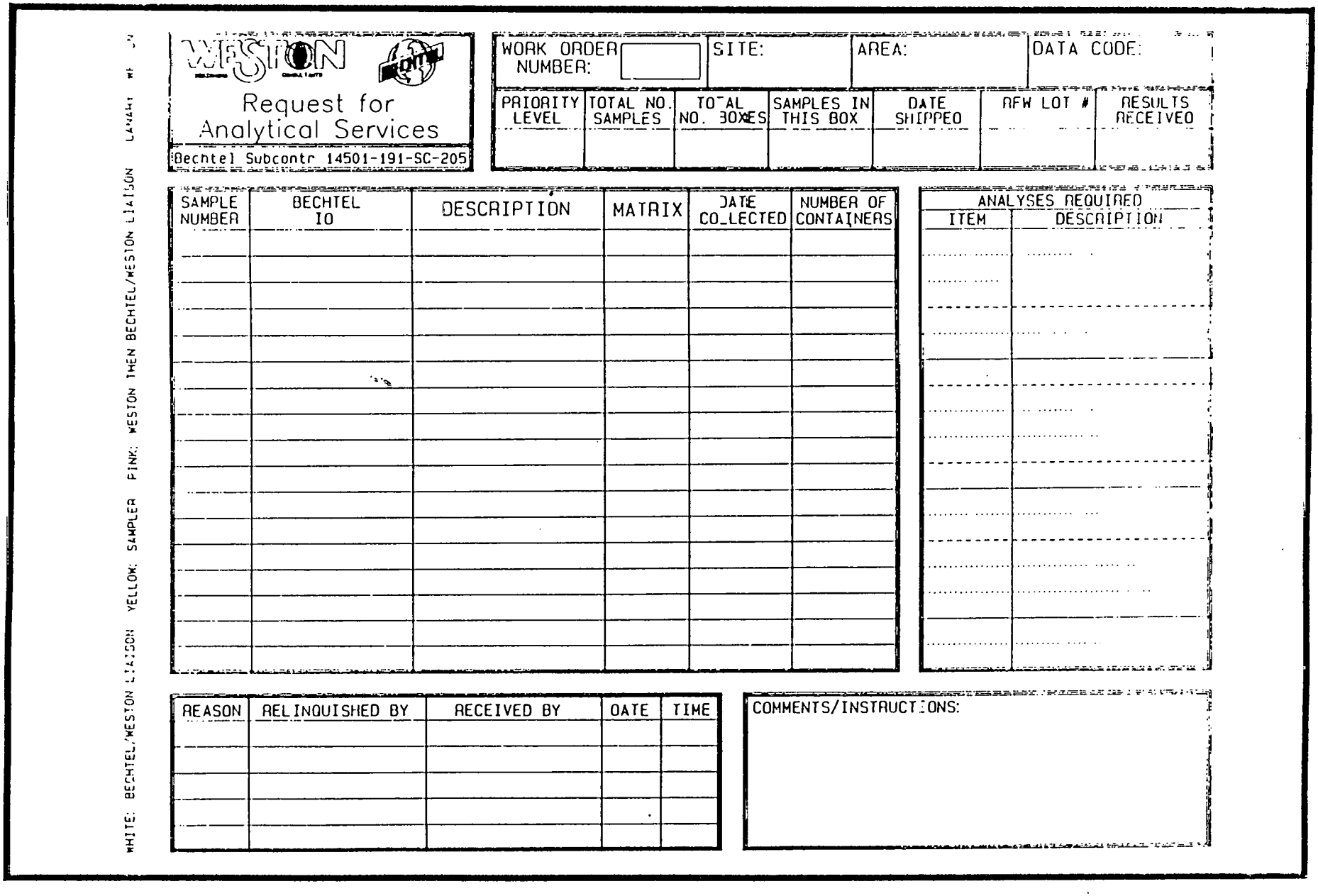
ITEM	DESCRIPTION
1.1.1	VOA
1.2.1	BNAE
1.7.1	PEST/PCB
5.0	ICPAES
5.36	RARE EARTHS
2.3	As - AA
2.7	Pb - AA
2.10	Se - AA
2.12	Tl - AA

PINK: BECHTEL/WESTON LIAISON

YELLOW: INITIATOR

WHITE: WESTON

FIGURE 4-2 COMPLETED ANALYTICAL SERVICES FORM



WHITE: BECHTEL/WESTON LIAISON YELLOW: SAMPLER PINK: WESTON THEN BECHTEL/WESTON LIAISON

WESTON

Request for Analytical Services

Bechtel Subcontr 14501-191-SC-205

WORK ORDER NUMBER:	SITE:	AREA:	DATA CODE:

PRIORITY LEVEL	TOTAL NO. SAMPLES	TOTAL NO. BOXES	SAMPLES IN THIS BOX	DATE SHIPPED	AFW LOT #	RESULTS RECEIVED

SAMPLE NUMBER	BECHTEL ID	DESCRIPTION	MATRIX	DATE COLLECTED	NUMBER OF CONTAINERS

ANALYSES REQUIRED	
ITEM	DESCRIPTION

REASON	RELINQUISHED BY	RECEIVED BY	DATE	TIME

COMMENTS/INSTRUCTIONS:

FIGURE 4-3 REQUEST FORM FOR ANALYTICAL SERVICES

Radiological samples

A strict chain-of-custody procedure was not used with the radiological samples. However, sample custody was tracked with a TMA/E sample collection form (Figure 4-4). The form was initiated when each sample was collected and followed the sample through the analytical procedures. When all sample analyses and necessary QA checks were completed in the laboratory, the unused portions of the samples and the sample containers were archived and will be retained until remedial action is complete. The independent verification contractor will archive a fraction of the samples for another five years (DOE 1986).

4.2.5 Data Reduction, Validation, and Reporting

Data reduction frequently includes computation of summary statistics and their standard errors, confidence intervals, testing of hypotheses relative to the parameters analyzed, and model validation.

Upon receipt of samples for radiological analysis (accompanied by a completed field sample collection form), chemists and/or technicians performed the analyses using approved analytical procedures, recorded the results in the parameter workbook, and detailed all procedural modifications, deviations, or problems associated with the analyses. Upon completion of an analytical procedure, all sample analysis data were subjected to a technical review by a designated representative of BNI. The analytical results were reviewed for precision, accuracy, completeness, and representativeness. Upon completion of the review, BNI either requested another measurement or approved the data for inclusion in a final data report. Upon successful completion of the QA/QC process, data were examined and evaluated by project personnel and transferred to the central database. After this process was completed, any further alteration to the data was documented. All data generated were compared with relevant and applicable standards to aid in an assessment of environmental risk.

The purpose of the chemical analytical program was to receive data at a Contract Laboratory Program (CLP) level of quality. The data report was an abbreviated version of the standard CLP report that emphasized sample results and quality control. Raw instrument data were neither requested nor received.

Exhibit B of the EPA CLP-SOW for both organics and inorganics analysis (EPA 1988a,b) was used as guidance for analytical and data reduction procedures and data reporting procedures to facilitate data validation. Analytes that are not included in the CLP (such as TOC and TOX) were reported in accordance with appropriate EPA procedures.

TMA/Eberline

Form 4A.1

FIELD SAMPLE COLLECTION FORM

SITE ACTIVITY SAMPLES

Site WBS #_____ Site Name_____ Activity Support (Job#)_____ Sampler_____

Sample Grid Point ID	Sample Type (1)	Sample Time	Date Sample Collected	Preserved With	Purpose (2)	Analyses Required	Remarks

Sample Type (1)		Purpose (2)	
Surface Soil	SS	Rad Character	RC
Bias Soil	BS	Verification	VR
Profile Soil	PS	Quality Control	QC
Sediment Silt	SD	Hot Spot	SP
Other	OR	Resample	RS
Vegetation	VE	Background	BG
Ground Water	GW	Routine	RT
Surface Water	SW	Special	SP

Recorded By_____ Date/Time_____

Total Number of Samples_____

Shipping Carrier_____ Date/Time_____

CHAIN OF CUSTODY

REASON	RELNQ. BY	RECEIVED BY	DATE	TIME

FIGURE 4-4 FIELD SAMPLE COLLECTION FORM

Data were reported in a standard format by RFW. TCL organic compounds were reported on data summary sheets. In addition, the laboratory was required to report a maximum of 30 EPA/National Institutes of Health Mass Spectral Library searches for nonpriority pollutant compounds. These searches are conducted to tentatively identify and estimate the concentration of 10 volatile fraction peaks and 20 BNAE fraction peaks.

Each routine analytical services abbreviated data package included the following:

- General information and header information
- Organics analysis data sheets
- Surrogate recovery information
- Matrix spike/matrix spike duplicate recovery information
- Method blank summary
- Pesticide/PCB identification
- Analytical data
- Sample shipping logs

Each inorganics data package included the following:

- General information and header information
- Cover page -- inorganics analyses data package
- Inorganics analysis data sheets
- Contract-required detection limit standard for atomic absorption and inductively coupled plasma atomic emission spectrophotometry
- Blanks
- Spike sample recovery information
- Post-digest spike sample recovery
- Duplicates
- Laboratory control samples
- Instrument detection limits
- Analytical data
- Sample shipping logs

The following references were used as guidance for analytical and data reduction procedures:

Methods for Chemical Analysis of Water and Wastes, Section 200, "Metals" (EPA 1983)

"Optical Emission Spectrometric Method for Trace Element Analysis of Water and Wastes" (44 FR 69559, Appendix IV)

Handbook for Analytical Quality Control in Water and Wastewater Laboratories, Chapter 7, "Data Handling and Reporting" (EPA 1979)

Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater (EPA 1982)

RFW was required to submit the data package to BNI within a prescribed time following receipt of sample, and TMA/E provided data reports and QC information within a specified time. BNI conducted a QA/QC compliance review of the data before release that consisted of technical and administrative review of each case, sample, and sample fraction for compliance with contractually required ranges on measures of precision and accuracy. The review examined data completeness and analytical results for surrogate spikes, matrix spikes, duplicate samples, blanks, and performance. Acceptability or unacceptability was determined separately for volatiles, semivolatiles, and inorganics using ranges specified in the subcontract. BNI retained all QA/QC documentation and released the actual data tabulation and, if applicable, a cover sheet explaining the reasons for rejecting the data.

The BNI database was used to store and retrieve site-specific analytical data. These data were placed in permanent storage in a central database to establish security. When these data have been reviewed by project personnel and transferred to the central database, they cannot be altered.

All evaluated data were presented to show detection limits, tabulated concentrations, and reporting qualifiers. A second set of tables was developed to show positive results only. Upon successful completion of the QA/QC process, the data packages were signed by the reviewer, indicating either that the data were acceptable for use or that restrictions were placed on the use of the data.

4.2.6 Audits

System QA audits of project activities were scheduled (usually on an annual basis) and conducted by the QA personnel to verify adherence with field and laboratory procedures and to evaluate the appropriateness and effectiveness of the procedures. Audit team leaders and auditors were trained and certified in accordance with project procedures. Technical specialists participated as auditors under the direction of the audit team leader when the nature of the activities being audited warranted.

Schedules for conducting audits were coordinated with appropriate management and were indicated on QA planning schedules. Audit reports were prepared for each audit conducted. Audit findings that required corrective action and followup were documented, tracked, and resolved, as verified by the project QA supervisor. A summary of the audit results will be provided in the RI report.

4.3 SUMMARY OF OTHER MAJOR PLANS

A CRP has been developed for the St. Louis site to ensure effective exchange of information with the general public. This plan was developed using previous DOE experience with the affected community, EPA guidance relative to community relations, and interviews conducted with key individuals in the affected community. The St. Louis site CRP summarizes background information, describes the history of community involvement, describes community relations strategies, provides a schedule of community relations activities, and lists affected and interested groups and individuals. This plan, which was tailored to the needs of the St. Louis site, provides for meaningful exchange of information on such matters as potential health impacts, environmental issues, remedial action plans, project costs, and specific site activities. The CRP for the St. Louis site is being issued as a separate document.

A sampling and analysis plan, currently being developed for the remaining data gap sampling to be conducted at the St. Louis site, consists of two individual documents, the field sampling plan and the quality assurance project plan. The field sampling plan directs the field work for all radiological and chemical remedial investigation activities. The quality assurance project plan briefly describes the protocols necessary to achieve the data quality objectives defined for the remaining sampling and provides some historical documentation of quality assurance procedures used in past characterization efforts.

5.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY TASKS

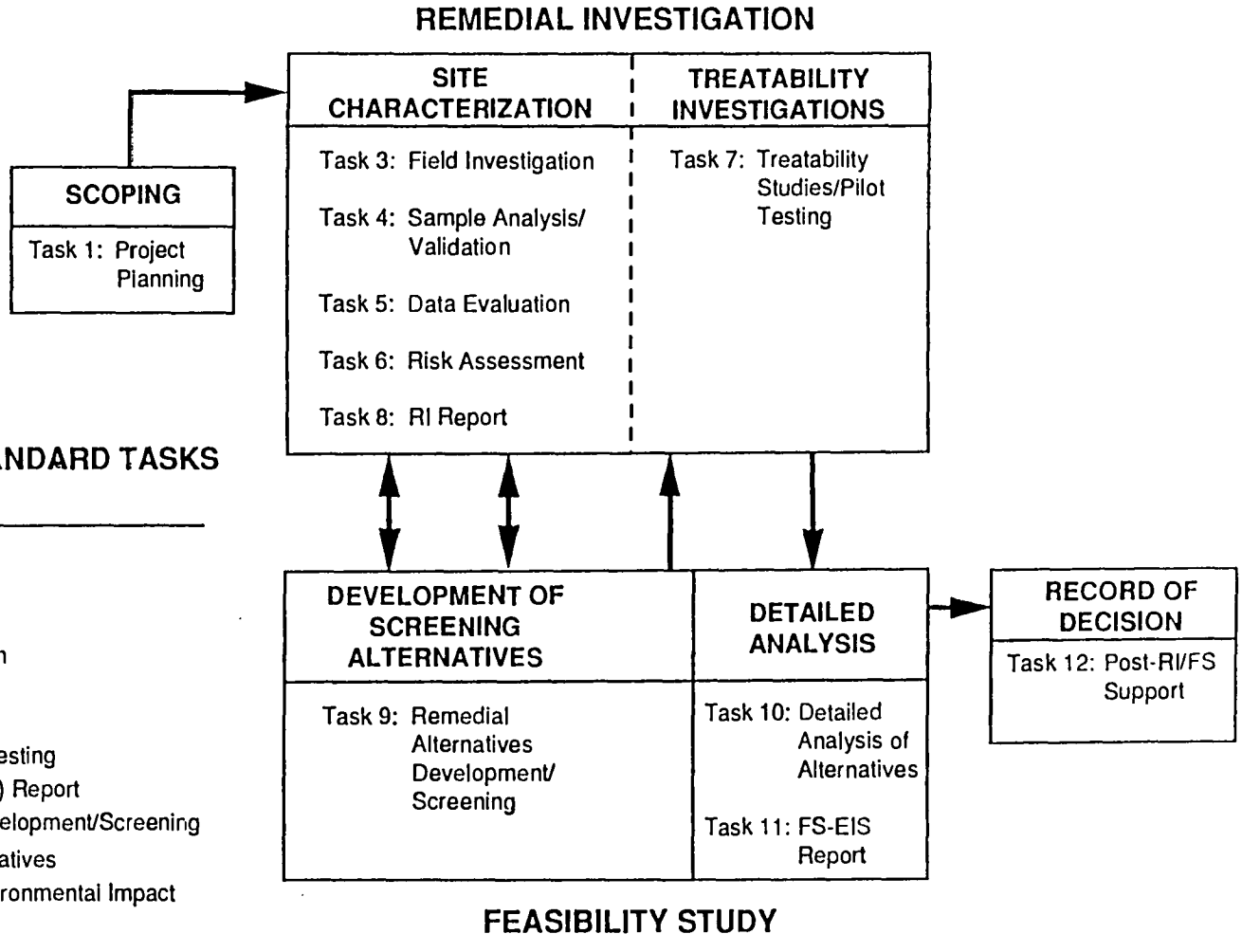
EPA has defined 14 standard tasks as composing the RI/FS process in Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988c). These tasks will be used in implementing the RI/FS-EIS process for the St. Louis site and should enhance coordination with EPA Region VII, MDNR, and local citizens and officials. The RI/FS tasks and the phased approach suggested by EPA are shown in Figure 5-1 and are briefly described in Subsections 5.1 through 5.14. Reference is made to other sections of this work plan or other project documents to explain the means by which these 14 tasks are being implemented for the St. Louis site.

All characterization for the St. Louis site has been completed. Some minor data gaps remain (see Subsection 3.8).

5.1 TASK 1: PROJECT PLANNING

The project planning task initiated the RI/FS-EIS process and established the project basis by:

- Collecting and documenting scoping information (Sections 1.0 and 2.0) and preparing an EIS implementation plan
- Collecting and evaluating existing data (Subsections 2.1, 2.2, and 2.3)
- Developing a site model (Subsection 3.4)
- Identifying preliminary response objectives and potential remedial action alternatives (Subsections 3.5 and 3.6)
- Identifying operable units and potential removal actions (Subsection 3.7)
- Identifying various feasibility studies to support the RI/FS-EIS process (Subsection 3.8)
- Compiling a list of potential federal ARARs (Subsection 3.9)
- Determining data needs and defining DQOs (Subsections 3.8, 4.1, and 4.2)
- Documenting RI/FS tasks (Section 5.0)
- Developing schedules for completion of major project elements (Section 6.0)
- Identifying project organization and project management (Section 7.0)



RI/FS WORK PLAN STANDARD TASKS

Task	Title
1.	Project Planning
2.	Community Relations*
3.	Field Investigation
4.	Sample Analysis/Validation
5.	Data Evaluation
6.	Risk Assessment
7.	Treatability Studies/Pilot Testing
8.	Remedial Investigation (RI) Report
9.	Remedial Alternatives Development/Screening
10.	Detailed Analysis of Alternatives
11.	Feasibility Study (FS)-Environmental Impact Statement (EIS) Report
12.	Post-RI/FS Support
13.	Enforcement Support*
14.	Miscellaneous Support*

*Tasks that can occur in any stage of the RI/FS

FIGURE 5-1 RELATIONSHIP OF RI/FS TASKS TO PHASED RI/FS APPROACH

All of these elements are included in this work plan, which constitutes an overview of project planning for the St. Louis site RI/FS-EIS process. All project scoping required under CERCLA has been completed. The results of the NEPA scoping process, which has not yet been completed, will be summarized in an EIS implementation plan that will be appended to this work plan. The NEPA scoping process cannot be completed until a public meeting describing the proposed actions at the St. Louis site has taken place. Many elements described in this work plan are summaries of more comprehensive documents. Each of the summaries contained in this work plan reflects the current status of the respective task.

5.2 TASK 2: COMMUNITY RELATIONS

Task 2 incorporates all efforts related to preparation and implementation of the CRP. Community relations activities for the St. Louis site have been conducted since 1982, and a CRP has been prepared consistent with EPA requirements. These efforts will continue until the RI/FS process has been completed and the selected remedy is implemented. The CRP for the St. Louis site includes background information about the site, the history of community involvement, community relations strategies, a schedule of community relations activities, and a list of affected and interested groups and individuals. The CRP also addresses interviews with members of the community to determine (1) citizen concerns, (2) information needs, and (3) how and when citizens wish to be involved in the RI/FS process. The CRP describes the activities that DOE will undertake to ensure a full program of public participation.

DOE has been providing information about its remedial action activities to officials, environmental groups, and the media in the St. Louis area for several years through news releases, fact sheets, and briefings. These mechanisms will continue to be used to inform the public. Information repositories have been established at the St. Louis Public Library (1301 Olive Street, St. Louis) and at the Prairie Commons Branch, St. Louis County Library System (915 Utz Lane, Hazelwood) to provide the public with access to documentation relating to the RI/FS process, including transcripts of related public meetings.

5.3 TASK 3: FIELD INVESTIGATION

Task 3 includes all efforts related to RI field work, including procurement of field subcontractors. The task begins when any element, as outlined in the work plan, is approved and is

complete when the contractors leave the field. The following activities are typically included in the task:

- Mobilization
- Media sampling
- Source testing
- Geophysical investigations
- Geological and hydrogeological investigations
- Site surveys and topographic mapping
- Field measurements and analyses
- Procurement of subcontracts
- RI waste disposal
- Task management and quality control

All major field investigations at the St. Louis site have been completed.

5.4 TASK 4: SAMPLE ANALYSIS AND VALIDATION

This task includes all efforts relating to analysis and validation of samples after they leave the field to ensure that they meet the DQOs established for the project. Control and verification of the integrity of project data were ensured through the technical specifications established for analytical subcontractors and through review of QC data. Quality control was accomplished by internal and external audits, analyses of QC samples, and participation in laboratory intercomparison tests.

Sample analyses were performed by two independent laboratories subcontracted by BNI. RFW Analytical Laboratories analyzed those samples requiring chemical analyses following the technical specifications set forth in the BNI/RFW subcontract. TMA/E performed the radiological analyses using standard industry practices and DOE-accepted methods, specifically EML-300 and EPA-600 procedures.

Efforts were made to ensure that analytical data were sufficiently accurate and precise to meet the appropriate level of data quality for a particular piece of information. The integrity of data was ensured by checking the QC data associated with the sample analysis. The quality of the data was evaluated by checking the data using information from the QC samples to ensure that the results obtained provided meaningful data that could be used in design engineering for remedial action.

Although QC data differ for each type of data generated (e.g., field gamma scan, radioisotopic analyses, volatile organic analyses, and RCRA characteristics tests), they can be used to evaluate common elements including completeness of data, acceptability of detection limits, indications of field or laboratory contamination of samples, and reproducibility of results.

5.5 TASK 5: DATA EVALUATION

Task 5 involves evaluating the data after they have been validated under Task 4. The task begins when the first set of validated data is received and ends during preparation of the RI report when it is determined that no additional data are required.

Data evaluation tasks are intended to provide the information needed to complete the RI/FS-EIS process. For example, validated groundwater data collected during the RI should complete the understanding of the groundwater system at the St. Louis site. The measured concentrations of uranium, thorium, radium, and various chemical contaminants in the aquifers--in connection with identified groundwater receptors--will enable calculation of the potential health risk to members of the public who may drink this groundwater.

Typical products of the data evaluation task for the St. Louis site include drawings delineating the boundaries of contamination for the different contaminants present, tables listing contaminant concentrations for the various media, quantification of migration pathways as appropriate, and tabulation of engineering data (such as waste volume) necessary for evaluating the remedial action alternatives. All calculations were documented in calculation logs and checked by an independent reviewer before sign-off. Where computations were performed with computer programs, either validated software was used or the calculation methods were hand-verified. Results will be provided in the RI report.

5.6 TASK 6: RISK ASSESSMENT

Task 6 consists of assessing potential risks to human health and the environment. It includes assessing baseline risks during the RI, setting preliminary performance goals for conducting the FS, and comparing risks for evaluated alternatives. Work begins during the data evaluation task and ends during the evaluation of remedial action alternatives. Efforts on Task 6 have been initiated (see schedule in Section 6.0).

Initial evaluation of currently available data (see Section 2.0) indicates chemical and radioactive contamination at SLDS. At SLAPS, HISS, Futura, and all vicinity properties, radioactive

contamination is the primary concern; however, elevated levels (i.e., higher than background) of metals traceable to the original processes conducted at SLDS were found at these properties.

The baseline risk assessment being conducted for the St. Louis site will analyze, for current and future land uses, the potential adverse human health and environmental effects caused by hazardous substance releases from a site in the absence of any actions to control or mitigate these releases. The baseline risk assessment will evaluate hazards posed by current site conditions by analyzing the environmental transport pathways to potential receptors from areas where radioactive and chemical contaminants are currently located. The results of the assessment will also assist in screening alternatives and determining acceptable levels of residual contamination (i.e., cleanup limits) for radioactive and chemical constituents.

Human health risk assessments for both chemicals and radionuclides will be conducted based on the approaches outlined in EPA's Risk Assessment Guidance for Superfund (EPA 1989). The steps in risk assessment are (1) identification of contaminants of concern, (2) assessment of exposure, (3) assessment of toxicity, and (4) characterization of risk. Contaminants to be assessed are radionuclides and those chemicals for which DOE has responsibility under the federal facilities agreement.

Pertinent pathways for the St. Louis site include inhalation of contaminants through contaminated dust particles, ingestion of contaminated soils, inhalation of radon-222 decay products, and external gamma radiation exposure.

The exposure levels of the chemicals and radionuclides at exposure points will be estimated using characterization and monitoring data as much as feasible and will be utilized to arrive at both current and future land use risk assessments. Information from the literature and earlier site studies regarding environmental chemistry and contaminant fates will be considered and incorporated, where valid and applicable, in all estimates of chemical and radionuclide exposure point concentrations.

Chemical and radiological risks will be analyzed separately to allow for a clear presentation of the source of risk, i.e., radiological or chemical. Combining the radiological and chemical risks could mask information that might aid in the selection of the appropriate remedy.

Because a major portion of the St. Louis site is in heavily industrialized areas, the species that exist at the site may be exposed to site-related contamination and other sources of contamination. The ecological assessment for the site will be at a level appropriate to current site conditions. It will be limited in scope, and it is expected to be qualitative in nature.

5.7 TASK 7: TREATABILITY STUDIES AND PILOT TESTING

Task 7 includes efforts related to the performance of pilot-scale, bench-scale, and treatability studies. It also includes any post-screening investigations. Such studies will likely be necessary for the St. Louis wastes to test volume reduction or treatment technologies that have not yet been proven reliable or effective in full-scale operation or to develop sufficient preliminary design information on which to base evaluations of remedial action alternatives in the FS. Several potential remedial action technologies that may require bench- or pilot-scale treatability studies have been identified for the St. Louis site (see Subsection 3.6). These will be performed if the results of characterization and engineering studies indicate the need for them.

5.8 TASK 8: REMEDIAL INVESTIGATION REPORT

This task involves preparation of the findings after the data have been evaluated under Tasks 5 and 6. The task covers all draft and final RI reports as well as task management and quality control. The following are typical activities:

- Preparing a preliminary site characterization summary (formatting tables, preparing graphics)
- Writing the report
- Reviewing and providing QC efforts
- Printing and distributing the report
- Holding review meetings
- Revising the report on the basis of agency comments

The proposed RI report outline format for the St. Louis site is provided in Table 5-1.

5.9 TASK 9: REMEDIAL ALTERNATIVES DEVELOPMENT AND SCREENING

Task 9 involves the initial development and evaluation of remedial action alternatives that will be fully evaluated under Task 10. The objective of the Task 9 screening process is to narrow the range of alternatives that will undergo full evaluation. The process begins with refinement of the remedial response objectives, proceeds through narrowing of the potential technologies based on

TABLE 5-1

OUTLINE FOR THE ST. LOUIS SITE

REMEDIAL INVESTIGATION REPORT

EXECUTIVE SUMMARY

1.0 INTRODUCTION
- 1.1 Purpose
- 1.2 Site Background
- 1.3 Report Organization

2.0 STUDY AREA INVESTIGATIONS
- 2.1 Field Activities
- 2.2 Meteorological Investigation

3.0 NATURE AND EXTENT OF CONTAMINATION
- 3.1 Background Measurements
- 3.2 Characterization Results for SLDS
- 3.3 Characterization Results for the SLDS Vicinity Properties
- 3.4 Characterization Results for SLAPS
- 3.5 Characterization Results for the SLAPS Vicinity Properties
- 3.6 Characterization Results for HISS
- 3.7 Characterization Results for Futura
- 3.8 Characterization Results for the Latty Avenue Vicinity Properties
- 3.9 Characterization Results for Intersections Between HISS and West Lake Landfill

4.0 POTENTIAL CONTAMINANT TRANSPORT PATHWAYS
- 4.1 Groundwater
- 4.2 Surface Water and Sediments
- 4.3 Air
- 4.4 Summary

5.0 SUMMARY AND CONCLUSIONS
- 5.1 Nature and Extent of Contamination
- 5.2 Date Limitations and Future Work
- 5.3 Objectives for Remedial Action Alternatives

REFERENCES AND BIBLIOGRAPHY

APPENDIX

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applicability and effectiveness, and ends with identification of a set of remedial action alternatives. Each remedial action alternative may involve application of a single technology or a combination of two or more technologies. Task 9 consists of the following activities:

- Identifying response objectives and response actions
- Listing potential remedial technologies
- Screening remedial technologies and process options based on site-specific criteria
- Assembling potential remedial action alternatives from the screened technologies and process options
- Evaluating potential remedial action alternatives based on screening criteria (i.e., effectiveness, implementability, and cost)
- Identifying candidate remedial action alternatives for detailed evaluation in Task 10

5.10 TASK 10: DETAILED ANALYSIS OF ALTERNATIVES

Task 10 involves detailed analysis and comparison of remedial alternatives. The following criteria are used to evaluate the alternatives that remain under consideration after Task 9 is complete:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume
- Short-term effectiveness
- Implementability
- Cost
- Acceptance by the state
- Acceptance by the community

A summary of each alternative, including the no-action alternative, is prepared using these nine criteria. The relative advantages and disadvantages are then used to compare and evaluate the remedial action alternatives. Use of these nine criteria is consistent with the new NCP.

5.11 TASK 11: FEASIBILITY STUDY-ENVIRONMENTAL IMPACT STATEMENT REPORT

Similar to Task 8 (RI report task), Task 11 involves the coordination and preparation of the FS-EIS report. The task is complete when the FS-EIS report is released to the public. The following are Task 11 activities:

- Formatting data for reporting purposes
- Preparing associated graphics
- Writing the report
- Printing and distributing the report
- Holding review meetings
- Revising the report based on agency comments

Table 5-2 provides the outline of a typical FS report based on the EPA-recommended format given in EPA's most recent guidance document (EPA 1988c). This outline will be modified to incorporate NEPA-related issues that are beyond the scope of a typical FS. The outline of the FS-EIS will be prepared following the public scoping meeting and will be included in the EIS implementation plan that will be appended to this work plan.

5.12 TASK 12: POST-REMEDIAL INVESTIGATION/FEASIBILITY STUDY SUPPORT

Task 12 includes efforts to prepare the proposed plan and responsiveness summary, support development of the ROD, and conduct any predesign activities. Task 12 activities include:

- Preparing the proposed plan
- Attending public meetings
- Preparing the responsiveness summary and draft ROD
- Finalizing documents in response to agency and public comments
- Preparing the predesign report
- Completing the conceptual design

TABLE 5-2

OUTLINE FOR THE ST. LOUIS SITE FEASIBILITY STUDY REPORT

EXECUTIVE SUMMARY

1.0 INTRODUCTION
- 1.1 PURPOSE AND ORGANIZATION OF REPORT
- 1.2 BACKGROUND INFORMATION (Summarized from RI Report)
  - 1.2.1 Site Description
  - 1.2.2 Site History
  - 1.2.3 Nature and Extent of Contamination
  - 1.2.4 Contaminant Fate and Transport
  - 1.2.5 Baseline Risk Assessment

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES
- 2.1 INTRODUCTION
- 2.2 REMEDIAL ACTION OBJECTIVES - Presents the development of remedial action objectives for each medium of interest (i.e., groundwater, soil, surface water, air, etc.). For each medium, the following should be discussed:
  - Contaminants of interest
  - Allowable exposure based on risk assessment (including ARARs)
  - Development of remediation goals
- 2.3 GENERAL RESPONSE ACTIONS - For each medium of interest, describes the estimation of areas or volumes to which treatment, containment, or exposure technologies may be applied.
- 2.4 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS - For each medium of interest, describes:
  - 2.4.1 Identification and Screening of Technologies
  - 2.4.2 Evaluation of Technologies and Selection of Representative Technologies

3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES
- 3.1 DEVELOPMENT OF ALTERNATIVES - Describes rationale for combination of technologies/media into alternatives. Note: This discussion may be by medium or for the site as a whole.
- 3.2 SCREENING OF ALTERNATIVES (If conducted)
  - 3.2.1 Introduction
  - 3.2.2 Alternative 1
    - 3.2.2.1 Description
    - 3.2.2.2 Evaluation
  - 3.2.3 Alternative 2
    - 3.2.3.1 Description
    - 3.2.3.2 Evaluation
  - 3.2.4 Alternative 3

TABLE 5-2
(continued)

4.0 DETAILED ANALYSIS OF ALTERNATIVES
- 4.1 INTRODUCTION
- 4.2 INDIVIDUAL ANALYSIS OF ALTERNATIVES
  - 4.2.1 Alternative 1
    - 4.2.1.1 Description
    - 4.2.1.2 Assessment
  - 4.2.2 Alternative 2
    - 4.2.2.1 Description
    - 4.2.2.2 Assessment
  - 4.2.3 Alternative 3
- 4.3 COMPARATIVE ANALYSIS

BIBLIOGRAPHY

APPENDICES

The proposed plan is a summary document (typically fewer than 10 pages) that identifies the preferred remedial action alternative and the reasons for the preference, describes the alternatives evaluated in the RI/FS, and solicits public review and comment on all screened alternatives presented in the FS. An annotated outline for the proposed plan developed from EPA guidance is shown in Table 5-3. Preparation of the responsiveness summary and ROD will be initiated following public review of the RI/FS.

5.13 TASK 13: ENFORCEMENT SUPPORT

This task includes efforts during the RI/FS process associated with enforcement aspects of the project, typically concerning potentially responsible parties. Because DOE has assumed responsibility for the St. Louis site, Task 13 is not applicable to this project.

5.14 TASK: 14 MISCELLANEOUS SUPPORT

Task 14 is used to report on work that is associated with the project but does not fall under any of the other established RI/FS tasks. Task 14 activities will vary but may include the following:

- Specific support for coordination with and review of the RI/FS by the Agency for Toxic Substances and Disease Registry
- Support for review of special state or local projects

TABLE 5-3

OUTLINE FOR THE PROPOSED PLAN

STATEMENT OF PURPOSE OF DOCUMENT

To fulfill requirements of Section 117(a) of CERCLA
To describe alternatives analyzed
To identify preferred alternative and explain rationale for preference
To serve as companion to the RI/FS
To solicit community involvement in selection of a remedy

SITE DESCRIPTION

Identify site name and location
Summarize site history and problems to be addressed
Identify lead and support agencies

SCOPE AND ROLE OF RESPONSE ACTION

Summarize scope of problem the action will address
Describe role of action within site strategy

ALTERNATIVES ANALYZED

Briefly describe alternatives evaluated in detailed analysis of FS, including estimated cost and implementation time

PREFERRED ALTERNATIVE

Identify the preferred alternative
Introduce the nine evaluation criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

Provide rationale for preferred alternative by highlighting the trade-offs among the alternatives with respect to the nine criteria

State the lead agency's belief that the preferred alternative meets statutory findings

TABLE 5-3

(continued)

ROLE OF COMMUNITY IN PROCESS
Provide notice of public comment period (written comments are encouraged)
Note time and place for scheduled public meeting(s) or offer opportunity for a meeting
Identify lead and support agency contacts
Stress importance of public input on all alternatives
Locate administrative records and information repositories

6.0 PROJECT SCHEDULE

The overall schedule for the environmental compliance activities planned for the St. Louis site is shown in Figure 6-1. This schedule was developed in accordance with FUSRAP budget planning as of fiscal year 1990 and shows the events projected through the point at which the ROD is issued. This schedule shows the relationships between the tasks and their projected durations. Specific dates beyond 1990 should not be considered as firmly established, however, because funding is based on an out-year budget cycle. The project schedule consists of the following major components:

- Completion of scoping and planning for the site. Scoping involves the early incorporation of public comment and concerns into the RI/FS-EIS process. This may include, for example, consideration of specific remedies for site cleanup or evaluation of various health and environmental concerns. Documentation for the St. Louis site includes a RI/FS-EIS work plan, an EIS implementation plan that will be incorporated into the work plan after completion of the public scoping meetings, and a community relations plan.

- Completion of site characterization.

- Completion of the RI/FS-EIS process and issuance of associated reports (i.e., RI, baseline risk assessment, and FS-EIS reports) for public comment.

- Incorporation of public comments on the draft RI/FS-EIS and proposed plan in the final RI/FS-EIS and the responsiveness summary, which will describe the remedy selected for the St. Louis site. The ROD is projected to be issued in 1994. Remedial design and remedial action consistent with the NCP will be initiated following issuance of the ROD.

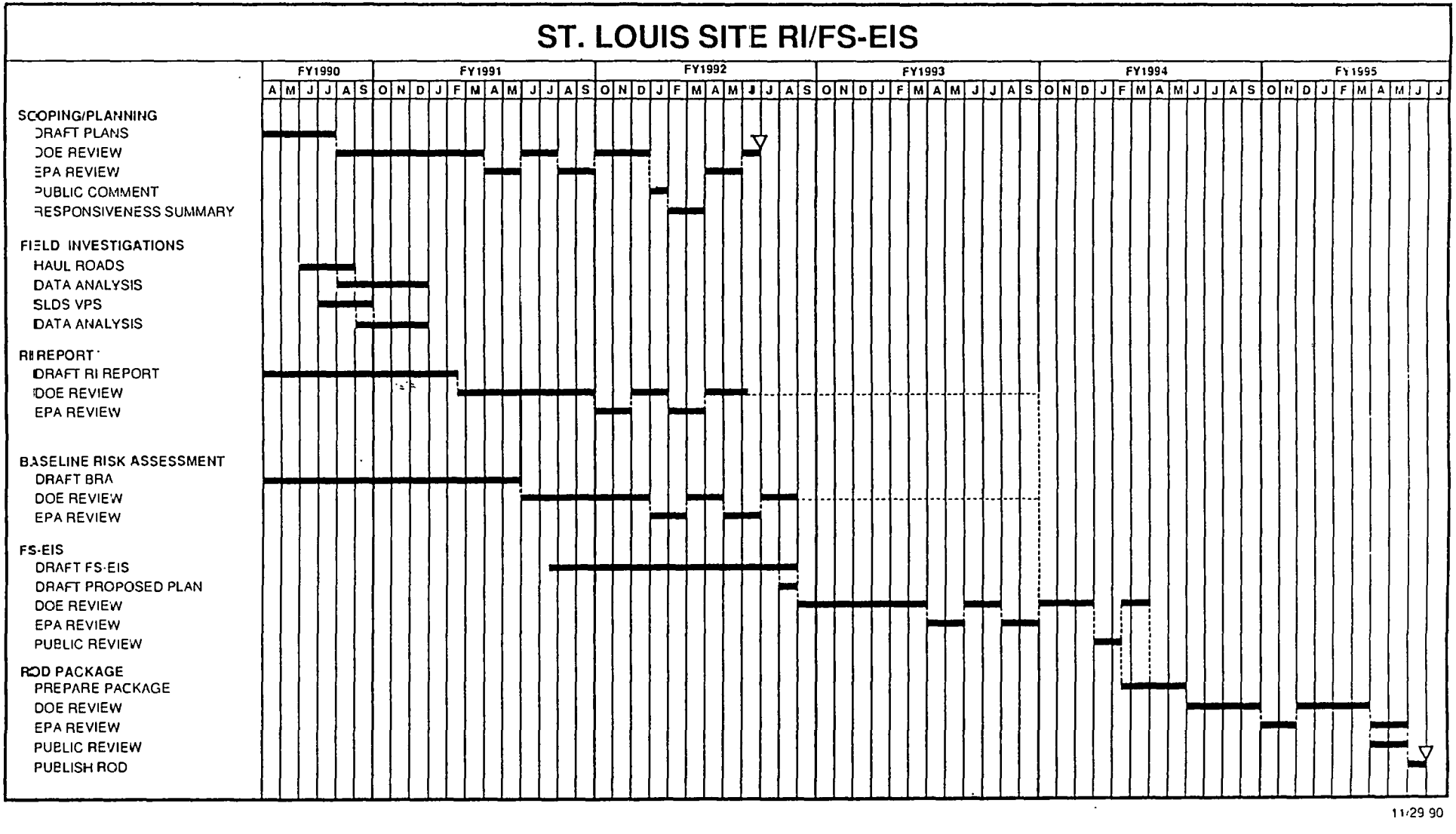

FIGURE 6-1 SCHEDULE FOR THE ST. LOUIS SITE

7.0 PROJECT MANAGEMENT

7.1 PROJECT ORGANIZATION

Remedial action at the St. Louis site is being conducted by DOE under FUSRAP, which is administered by the Eastern Area Programs Division of the Office of Environmental Restoration (see Figure 7-1). This division is responsible for policy decisions related to conducting remedial actions at the site. Responsibility for management and technical direction of remedial action activities for FUSRAP has been delegated to the DOE Field Office, Oak Ridge (DOE-OR). The Former Sites Restoration Division of DOE-OR manages the day-to-day activities of FUSRAP. DOE-OR has functional responsibility for preparation of the environmental compliance documents, although various groups at DOE Headquarters have review and concurrence authority. The Assistant Secretary for the Environment, Safety, and Health is responsible for approving publication of the RI/FS-EIS. A phased RI/FS-EIS process is being used for this action (see Figure 7-2).

Several organizations are under contract to DOE-OR to support implementation of FUSRAP. The two organizations responsible for preparation of the St. Louis site RI/FS-EIS are BNI and Science Applications International Corporation (SAIC). BNI, the project management contractor for remedial action activities at the St. Louis site, is responsible for the collection of all necessary site characterization and environmental data required for the RI report. SAIC, the environmental studies contractor, performs an independent analysis of the environmental impacts of remedial action alternatives in the FS-EIS, using information provided by BNI and others (e.g., the RI report and requisite technical, engineering, and cost studies) to support the detailed analyses required.

7.2 PROJECT COORDINATION AND RESPONSIBILITIES

Three organizations are under contract to DOE-OR to support the implementation of remedial actions at the St. Louis site (Figure 7-1). The responsibilities of the organizations are as follows:

- Bechtel National, Inc.
  - Provides overall project management support to DOE for the St. Louis site
  - Administers procurement and QA functions
  - Performs general administrative functions

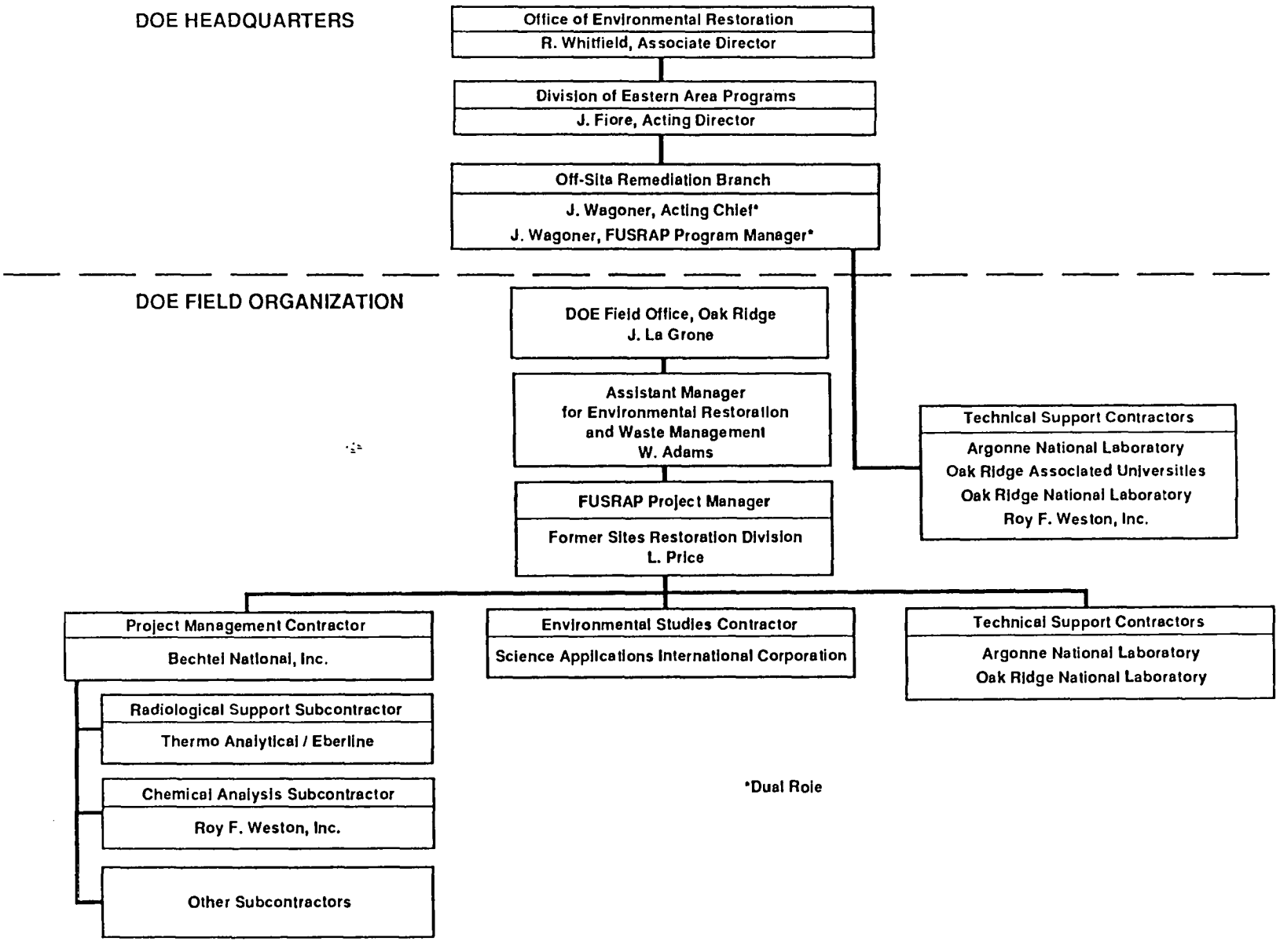

FIGURE 7-1 PROJECT ORGANIZATION

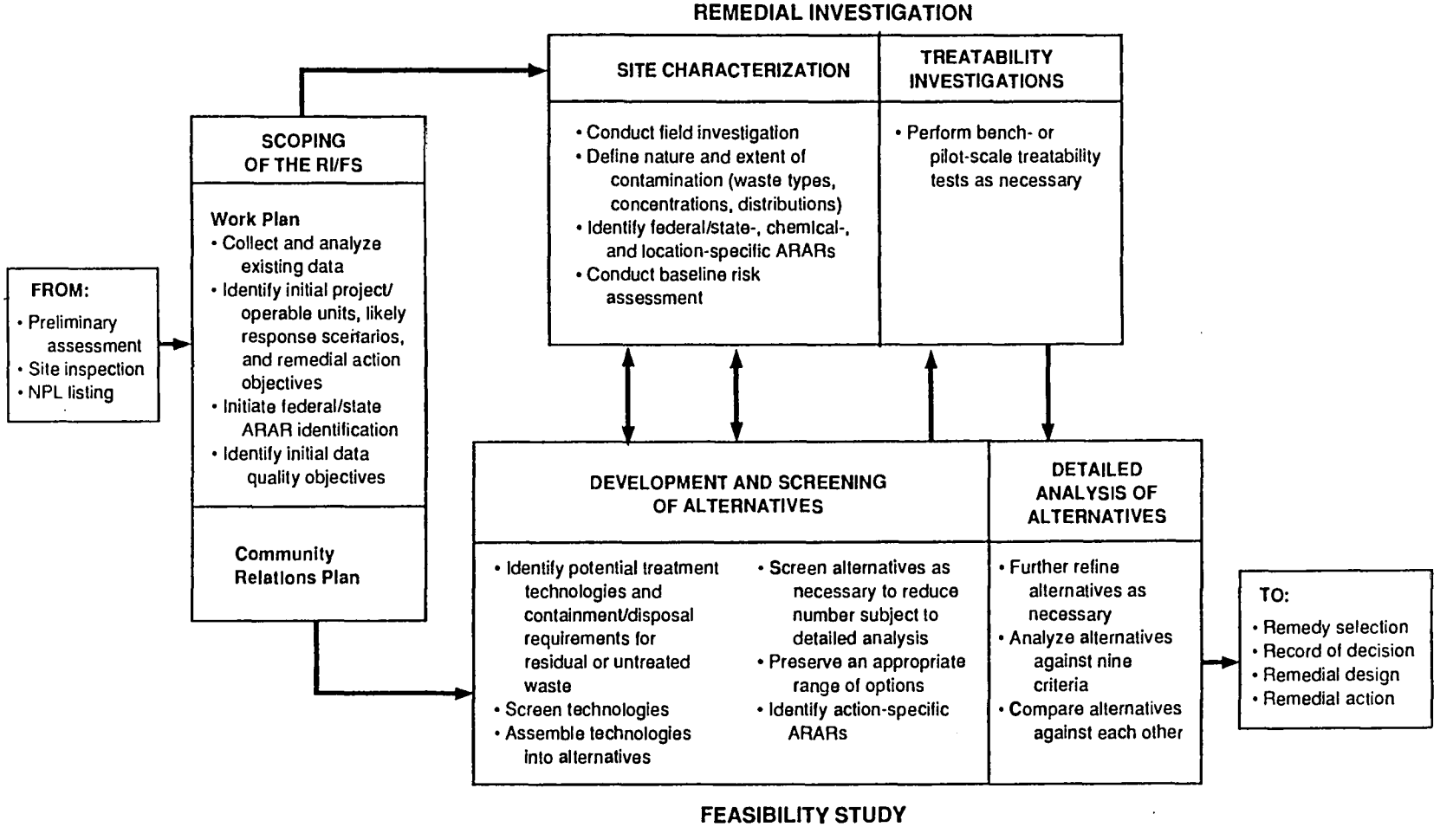

FIGURE 7-2 PHASED RI/FS PROCESS

- Administers all environmental, safety, and health programs at the site
- Directs all engineering activities
- Provides technical input to the preparation of environmental documents
- Performs community relations duties

- Science Applications International Corporation
  - Performs health and environmental analyses for the RI/FS-EIS process
  - Provides an independent analysis of environmental studies, engineering feasibility, and cost-effectiveness of response action alternatives performed by other DOE contractors
  - Prepares additional environmental compliance documentation as needed

- Oak Ridge National Laboratory
  - Provides technical support as needed

Four organizations (ANL, ORAU, ORNL, AND RFW; see Figure 7-1) provide technical support for FUSRAP to the Division of Eastern Area Programs. These organizations carry out the following functions:

- Conduct radiological surveys to identify and aid in designation of vicinity properties that require remedial action
- Conduct post-response action radiological surveys to provide an independent verification of the adequacy of the cleanup and prepare associated verification reports
- Perform technical review of FUSRAP documents

7.3 PROJECT CONTROLS

Project controls are implemented to provide detailed planning for cost, schedule, and technical performance to maximize efforts toward achievement of project goals. Project controls are implemented for the FUSRAP project as a whole because there are 33 sites in 13 states for which costs and schedules must be tracked and controlled. BNI has established and DOE has validated a system that conforms to the criteria for cost and schedule control systems developed by the U.S. Department of Defense. This system provides a basis for assessing the quality of the cost and schedule controls used by the project participants; aids in ensuring effective planning, management,

and control of project work; and provides a quick and effective means of measuring cost, schedule, and technical performance. This cost and schedule control system uses a work breakdown structure (WBS) to divide the total FUSRAP project into distinct sites and then into discrete work packages that can be effectively managed. The WBS also provides the framework for integrating budget requirements with schedule and technical performance. Finally, it establishes the management analysis and reporting structure to permit data presentation to various levels of management.

A project document control center (PDCC) is maintained at the BNI office in Oak Ridge, Tennessee, to collect, register, distribute, and retain all documents. Each document related to the St. Louis site is coded with a unique WBS number to associate the document with a particular St. Louis property. Subject codes are also assigned from predetermined categories that can be used to organize documents. The PDCC system provides for rapid identification and retrieval of all project documents by allowing documents to be searched/sorted by WBS number, subject code, author, recipient, transmittal date, a unique identification number, or any combination of the above.

All relevant information obtained during the RI/FS-EIS process for the St. Louis site is being retained by PDCC: aerial photographs, topographic maps, reports on features of the site and its surrounding area, correspondence involving the site, findings of previous surveys, and analytical data obtained during site characterization. Types of characterization data on file include radiological and chemical data based on analyses of soil, groundwater, and surface water; borehole logging data; air sampling data; and information about geological and soil properties. Well construction data and field notebooks and documentation (e.g., chain-of-custody forms) are also on file with PDCC.

TABLE FOR APPENDIX A

APPENDIX A
RELATED FEDERAL PROJECTS

The Department of Energy (DOE) has prepared environmental impact statement (EIS) documents for other programs and other sites under its remedial action program; these documents are similar to the documents that will be used as references in implementing the Comprehensive Environmental Response, Compensation, and Liability Act/National Environmental Policy Act (CERCLA/NEPA) process at the St. Louis Site. Examples include:

- Department of Energy, 1983, *Final Environmental Impact Statement, Remedial Actions at the Former Vitro Rare Metals Plant Site, Canonsburg, Washington County, Pennsylvania*, DOE/EIS-0096-F, 2nd vol., July.

- Department of Energy, 1984, *Final Impact Statements, Remedial Actions at the Former Vitro Chemical Company Site, South Salt Lake, Salt Lake County, Utah*, DOE/EIS-0099-F, 2nd vol., July.

- Department of Energy, 1984, *Final Environmental Impact Statement, Remedial Actions at the Former Vanadium Corporation of America Uranium Mill Site, Durango, La Plata County, Colorado*, DOE/EIS-0111-F, 2nd vol., October.

- Department of Energy, 1986, *Final Environmental Impact Statement, Remedial Actions at the Former Climax Uranium Company Uranium Mill Site, Grand Junction, Mesa County, Colorado*, DOE/EIS-0126-F, 2nd vol., December.

- Department of Energy, 1986, *Final Environmental Impact Statement, Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site*, DOE/EIS-0109-F, April.

In addition, the Nuclear Regulatory Commission and the Environmental Protection Agency have prepared EISs on various related programs, proposed standards, and specific sites, including:

- Environmental Protection Agency, 1982, *Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites* (40 CFR 192), Vols. 1 and 2; EOA 520/4/82-013-1, -2, October.

- Nuclear Regulatory Commission, 1983, *Final Environmental Statement Related to the Decommissioning of the Rare Earths Facility, West Chicago, Illinois, Docket No. 40-2-61, Kerr-McGee Chemical Corporation*, NUREG-0904, May.

- Environmental Protection Agency, 1986, *Final Environmental Impact Statement, Proposed Wastewater Treatment Facilities for Eastern St. Charles County, Missouri, Including: Duckett Creek Sewer District, St. Peters Sewer District, St Charles Sewer District, Portage de Sioux District*, EPA 907/9-86-003, May.

- Nuclear Regulatory Commission, 11989, *Final Supplement to the Final Environmental Statement Related to the Decommissioning of the Rare Earths Facility, West Chicago, Illinois, Docket No. 40-2061, Kerr-McGee Chemical Corporation*, NUREG-0904, Supplement No. 1, April.

Table A-1

Agencies with Whom Consultation Is Required by Law

Subject Area	Legislation	Agency
Endangered species	Endangered Species Act of 1973, as amended; state laws	U.S. Fish and Wildlife Service; state agencies
Migratory birds	Migratory Bird Treaty Act	U.S. Fish and Wildlife Service
Historic preservation	Archaeological and Historic Reservation Act of 1974; Archaeological Resources Protection Act of 1979	State Historic Preservation Office; President's Advisory Council
American Indian lands	American Indian Religious Freedom Act, as amended	Potentially affected Indian tribes
Work in navigable waters	Section 404 of Federal Water Pollution Control Act	Corps of Engineers
Prime and unique farmlands	Council on Environmental Quality (memo of August 30, 1976)	Soil Conservation Service
Floodplains	Executive Order 11988	Corps of Engineers; state agencies
Wetlands	Executive Order 11990	Corps of Engineers; state agencies
Water-body alteration	Fish and Wildlife Coordination Act	U.S. Fish and Wildlife Service; state agencies
Water and air pollution	Various water pollution and air emission acts and standards (e.g., Federal Water Pollution Control Act, Clean Air Act, Safe Drinking Water Act)	U.S. Environmental Protection Agency; state agencies
Land use	Federal Land Policy and Management Act of 1976	Soil Conservation Service
Water use and availability	Water Resources Planning Act of 1965; Safe Drinking Water Act; others	Office of Water Policy; state agencies

Table A-1

(continued)

Subject Area	Legislation	Agency
Air	Clean Air Act, as amended	U.S. Environmental Protection Agency; state agencies
Radiation	Various acts and standards (e.g., Clean Air Act, Safe Drinking Water Act)	U.S. Environmental Protection agency; state agencies
Noise	Noise Pollution and Abatement Act of 1970; Noise Control Act of 1972	U.S. Environmental Protection Agency; state agencies
Siting and planning	State siting acts; county zoning regulations	State and county agencies

APPENDIX B

DOE GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL

CHAPTER IV

RESIDUAL RADIOACTIVE MATERIAL

1. PURPOSE. This chapter presents radiological protection requirements and guidelines for cleanup of residual radioactive material and management of the resulting wastes and residues and release of property. These requirements and guidelines are applicable at the time the property is released. Property subject to these criteria includes, but is not limited to sites identified by the Formerly Utilized Sites Remedial Action Program (FUSRAP) and the Surplus Facilities Management Program (SFMP). The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactive material, and control of the radioactive wastes and residues. This chapter does not apply to uranium mill tailings or to properties covered by mandatory legal requirements.

2. IMPLEMENTATION. DOE elements shall develop plans and protocols for the implementation of this guidance. FUSRAP sites shall be identified, characterized, and designated, as such, for remedial action and certified for release. Information on applications of the guidelines and requirements presented herein, including procedures for deriving specific property guidelines for allowable levels of residual radioactive material from basic dose limits, is contained in DOE/CH 8901, "A Manual for Implementing Residual Radioactive Material Guidelines, A Supplement to the U.S. Department of Energy Guidelines for Residual Radioactive Material at FUSRAP and SFMP Sites," June 1989.

   a. Residual Radioactive Material This chapter provides guidance on radiation protection of the public and the environment from:

      (1) Residual concentrations of radionuclides in soil (for these purposes, soil is defined as unconsolidated earth material, including rubble and debris that might be present in earth material);

      (2) Concentrations of airborne radon decay products;

      (3) External gamma radiation;

      (4) Surface contamination; and

      (5) Radionuclide concentrations in air or water resulting from or associated with any of the above.

b. Basic Dose Limit. The basic dose limit for doses resulting from exposures to residual radioactive material is a prescribed standard from which limits for quantities that can be monitored and controlled are derived; it is specified in terms of the effective dose equivalent as defined in this Order. The basic dose limits are used for deriving guidelines for residual concentrations of radionuclides in soil. Guidelines for residual concentrations of thorium and radium in soil, concentrations of airborne radon decay products, allowable indoor external gamma radiation levels, and residual surface contamination concentrations are based on existing radiological protection standards (40 CFR Part 192; NRC Regulatory Guide 1.86 and subsequent NRC guidance on residual radioactive material). Derived guidelines or limits based on the basic dose limits for those quantities are used only when the guidelines provided in the existing standards are shown to be inappropriate.

c. Guideline. A guideline for residual radioactive material is a level of radioactive material that is acceptable for use of property without restrictions due to residual radioactive material. Guidelines for residual radioactive material presented herein are of two kinds, generic and specific. The basis for the guidelines is generally a presumed worst-case plausible-use scenario for the property.

(1) Generic guidelines, independent of the property, are taken from existing radiation protection standards. Generic guideline values are presented in this chapter.

(2) Specific property guidelines are derived from basic dose limits using specific property models and data. Procedures and data for deriving specific property guideline values are given by DOE/CH-8901.

d. Authorized Limit. An authorized limit is a level of residual radioactive material that shall not be exceeded if the remedial action is to be considered completed and the property is to be released without restrictions on use due to residual radioactive material.

(1) The authorized limits for a property will include:

(a) Limits for each radionuclide or group of radionuclides, as appropriate, associated with residual radioactive material in soil or in surface contamination of structures and equipment;

(b) Limits for each radionuclide or group of radionuclides, as appropriate, in air or water; and

(c) Where appropriate, a limit on external gamma radiation resulting from the residual material.

(2) Under normal circumstances expected at most properties, authorized limits for residual radioactive material are set equal to, or below, guideline values. Exceptional conditions for which authorized limits might differ from guideline values are specified in paragraphs IV-5 and IV-7.

(3) A property may be released without restrictions if residual radioactive material does not exceed the authorized limits or approved supplemental limits, as defined in paragraph IV.7a, at the time remedial action is completed. DOE actions in regard to restrictions and controls on use of the property shall be governed by provisions in paragraph IV.7b. The applicable controls and restrictions are specified in paragraph IV.6 and IV.7.c.

e. ALARA Applications. The monitoring, cleanup, and control of residual radioactive material are subject to the ALARA policy of this Order. Applications of ALARA policy shall be documented and filed as a permanent record.

3. BASIC DOSE LIMITS.

a. Defining and Determining Dose Limits. The basic public dose limits for exposure to residual radioactive material, in addition to natural occurring "background" exposures, are 100 mrem (1 mSv) effective dose equivalent in a year, as specified in paragraph II.1a.

b. Unusual Circumstances. If, under unusual circumstances, it is impracticable to meet the basic limit based on realistic exposure scenarios, the respective project and/or program office may, pursuant to paragraph II.1a(4), request from EH-1 for a specific authorization for a temporary dose limit higher than 100 mrem (1 mSv), but not greater than 500 mrem (5 mSv), in a year. Such unusual circumstances may include temporary conditions at a property scheduled for remedial action or following the remedial action. The ALARA process shall apply to the selection of temporary dose limits.

4. GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL.

a. Residual Radionuclides in Soil. Generic guidelines for thorium and radium are specified below. Guidelines for residual concentrations of other radionuclides shall be derived from the basic dose limits by means of an environmental pathway analysis using specific property data where available. Procedures for these derivations are given in DOE/CH-8901. Residual concentrations of radioactive material in soil are defined as those in excess of background concentrations averaged over an area of 100 m^2.

(1) Hot Spots. If the average concentration in any surface or below-surface area less than or equal to 25 m^2, exceeds the limit or guideline by a factor of $(100/A)^{0.5}$, [where A is the area (in square meters) of the region in which concentrations are elevated], limits for "hot-spots" shall also be developed and applied. Procedures for calculating these hot-spot limits, which depend on the extent of the elevated local concentrations, are given in DOE/CH-8901. In addition, reasonable efforts shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

(2) Generic Guidelines. The generic guidelines for residual concentrations of Ra-226, Ra-228, Th-230, and Th-232 are:

(a) 5 pCi/g, averaged over the first 15 cm of soil below the surface; and

(b) 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface.

(3) Ingrowth and Mixtures. These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If both Th-230 and Ra-226 or both Th-232 and Ra-228 are present and not in secular equilibrium, the appropriate guideline is applied as a limit for the radionuclide with the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that either the dose for the mixtures will not exceed the basic dose limit or the sum of the ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1. Explicit formulas for calculating residual concentration guidelines for mixtures are given in DOE/CH-8901.

b. Airborne Radon Decay Products. Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for release without restriction; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR Part 192) is: In any occupied or habitable building, the objective of remedial action shall be, and a reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL. [A working level (WL) is any combination of short-lived radon decay products in 1 L of air that will

result in the ultimate emission of 1.3 x 10^5 MeV of potential alpha energy.] In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions by DOE are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive material is not the source of the radon concentration.

c. External Gamma Radiation. The average level of gamma radiation inside a building or habitable structure on a site to be released without restrictions shall not exceed the background level by more than 20 μR/h and shall comply with the basic dose limit when an "appropriate-use" scenario is considered. This requirement shall not necessarily apply to structures scheduled for demolition or to buried foundations. External gamma radiation levels on open lands shall also comply with the basic limit and the ALARA process, considering appropriate-use scenarios for the area.

d. Surface Contamination. The generic surface contamination guidelines provided in Figure IV-1 are applicable to existing structures and equipment. These guidelines are generally consistent with standards of the NRC (NRC 1982) and functionally equivalent to Section 4, "Decontamination for Release for Unrestricted Use," of Regulatory Guide 1.86, but apply to nonreactor facilities. These limits apply to both interior equipment and building components that are potentially salvageable or recoverable scrap. If a building is demolished, the guidelines in paragraph IV.6a are applicable to the resulting contamination in the ground.

e. Residual Radionuclides in Air and Water. Residual concentrations of radionuclides in air and water shall be controlled to the required levels shown in paragraph II.1a and as required by other applicable Federal and/or State laws.

5. AUTHORIZED LIMITS FOR RESIDUAL RADIOACTIVE MATERIAL.

a. Establishment of Authorized Limits. The authorized limits for each property shall be set equal to the generic or derived guidelines unless it can be established, on the basis of specific property data (including health, safety, practical, programmatic and socioeconomic considerations), that the guidelines are not appropriate for use at the specific property. The authorized limits shall be established to (1) provide that, at a minimum, the basic dose limits of in paragraph IV.3, will not be exceeded under the "worst-case" or "plausible-use" scenarios, consistent with the procedures and guidance provided in DOE/CH-8901, or (2) be consistent with applicable generic guidelines. The authorized limits shall be consistent with limits and guidelines established by other applicable Federal and State laws. The authorized limits are developed through the project offices in the field and are approved by the Headquarters Program Office.

Figure IV-1
Surface Contamination Guidelines

Radionuclides[2/]	Allowable Total Residual Surface Contamination (dpm/100 cm²)[1/] Average[3/,4/]	Maximum[4/,5/]	Removable[4/,6/]
Transuranics, I-125, I-129, Ra-226, Ac-227, Ra-228, Th-228, Th-230, Pa-231.	RESERVED	RESERVED	RESERVED
Th-Natural, Sr-90, I-126, I-131, I-133, Ra-223, Ra-224, U-232, Th-232.	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay product, alpha emitters.	5,000	15,000	1,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.[7/]	5,000	15,000	1,000

1/ As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

2/ Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

3/ Measurements of average contamination should not be averaged over an area of more than 1 m². For objects of less surface area, the average should be derived for each such object.

4/ The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

5/ The maximum contamination level applies to an area of not more than 100 cm².

6/ The amount of removable material per 100 cm^2 of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wiping with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

7/ This category of radionuclides includes mixed fission products, including the Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.

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b. Application of Authorized Limits. Remedial action shall not be considered complete until the residual radioactive material levels comply with the authorized limits, except as authorized pursuant to paragraph IV.7 for special situations where the supplemental limits and exceptions should be considered and it is demonstrated that it is not appropriate to decontaminate the area to the authorized limit or guideline value.

6. CONTROL OF RESIDUAL RADIOACTIVE MATERIAL. Residual radioactive material above the guidelines shall be managed in accordance with Chapter II and the following requirements.

a. Operational and Control Requirements. The operational and control requirements specified in the following Orders shall apply to interim storage, interim management, and long-term management.

(1) DOE 5000.3, Unusual Occurrence Reporting System

(2) DOE 5440.1C, Implementation of the National Environmental Policy Act

(3) DOE 5480.4, Environmental Protection, Safety, and Health Protection Standards

(4) DOE 5482.1B, Environmental, Safety, and Health Appraisal Program

(5) DOE 5483.1A, Occupational Safety and Health Program for DOE Employees at Government-Owned, Contractor-Operated Facilities

(6) DOE 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements

(7) DOE 5820.2A, Radioactive Waste Management.

b. Interim Storage.

(1) Control and stabilization features shall be designed to provide, to the extent reasonably achievable, an effective life of 50 years with a minimum life of at least 25 years.

(2) Controls shall be designed such that Rn-222 concentrations in the atmosphere above facility surfaces or openings in addition to background levels, will not exceed:

(a) 100 pCi/L at any given point;

(b) An annual average concentration of 30 pCi/L over the facility site; and

(c) An annual average concentration of 3 pCi/L at or above any location outside the facility site.

(d) Flux rates from the storage of radon producing wastes shall not exceed 20 pCi/sq.m-sec., as required by 40 CFR Part 61.

(3) Controls shall be designed such that concentrations of radionuclides in the groundwater and quantities of residual radioactive material will not exceed applicable Federal or State standards.

(4) Access to a property and use of onsite material contaminated by residual radioactive material should be controlled through appropriate administrative and physical controls such as those described in 40 CFR Part 192. These control features should be designed to provide, to the extent reasonable, an effective life of at least 25 years.

c. Interim Management.

(1) A property may be maintained under an interim management arrangement when the residual radioactive material exceeds guideline values if the residual radioactive material is in inaccessible locations and would be unreasonably costly to remove, provided that administrative controls are established by the responsible authority (Federal, State, or local) to protect members of the public and that such controls are approved by the appropriate Program Assistant Secretary or Director.

(2) The administrative controls include but are not limited to periodic monitoring as appropriate; appropriate shielding; physical barriers to prevent access; and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactive material or cause it to migrate.

(3) The owner of the property should be responsible for implementing the administrative controls and the cognizant Federal, State, or local authorities should be responsible for enforcing them.

d. Long-Term Management.

(1) Uranium, Thorium, and Their Decay Products.

(a) Control and stabilization features shall be designed to provide, to the extent reasonably achievable, an effective life of 1,000 years with a minimum life of at least 200 years.

(b) Control and stabilization features shall be designed to limit Rn-222 emanation to the atmosphere from the wastes to less than an annual average release rate of 20 $pCi/m^2/s$ and prevent increases in the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates shall be in accordance with the requirements of 40 CFR Part 61.

(c) Before any potentially biodegradable contaminated wastes are placed in a long-term management facility, such wastes shall be properly conditioned so that the generation and escape of biogenic gases will not cause the requirement in paragraph IV.6d(1)(b) to be exceeded and that biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph IV.6d(1)(a).

(d) Ground water shall be protected in accordance with legally applicable Federal and State standards.

(e) Access to a property and use of onsite material contaminated by residual radioactive material should be controlled through appropriate administrative and physical controls such as those described in 40 CFR Part 192. These controls should be designed to be effective to the extent reasonable for at least 200 years.

(2) Other Radionuclides. Long-term management of other radionuclides shall be in accordance with Chapters II, III, and IV of DOE 5820.2A, as applicable.

7. SUPPLEMENTAL LIMITS AND EXCEPTIONS. If special specific property circumstances indicate that the guidelines or authorized limits established for a given property are not appropriate for any portion of that property, then the Operations Office may request that supplemental limits or an exception be applied. The responsible Operations Office shall document the decision that the subject guidelines or authorized limits are not appropriate and that the alternative action selected will provide adequate protection,

giving due consideration to health and safety, the environment, costs, and public policy considerations. The Operations Office shall obtain approval for specific supplemental limits or exceptions from Headquarters as specified in paragraph IV.5, and shall provide to the Headquarters Program Element those materials required by Headquarters for the justification as specified in this paragraph and in the FUSRAP and SFMP protocols and subsequent guidance documents. The Operations Office shall also be responsible for coordination with the State and local government regarding the limits or exceptions and associated restrictions as appropriate. In the case of exceptions, the Operations Office shall be responsible for coordinating with the State and/or local governments to ensure the adequacy of restrictions or conditions of release and that mechanisms are in place for their enforcement.

a. Supplemental Limits. Any supplemental limits shall achieve the basic dose limits set forth in Chapter II of this Order for both current and potential unrestricted uses of a property. Supplemental limits may be applied to any portion of a property if, on the basis of a specific property analysis, it is demonstrated that

   (1) Certain aspects of the property were not considered in the development of the established authorized limits for that property; and

   (2) As a result of these certain aspects, the established limits either do not provide adequate protection or are unnecessarily restrictive and costly.

b. Exceptions to the authorized limits defined for a property may be applied to any portion of the property when it is established that the authorized limits cannot reasonably be achieved and that restrictions on use of the property are necessary. It shall be demonstrated that the exception is justified and that the restrictions will protect members of the public within the basic dose limits of this Order and will comply with the requirements for control of residual radioactive material as set forth in paragraph IV.6.

c. Justification for Supplemental Limits and Exceptions. The need for supplemental limits and exceptions shall be documented by the Operations Office on a case-by-case basis using specific property data. Every reasonable effort should be made to minimize the use of supplemental limits and exceptions. Examples of specific situations that warrant DOE use of supplemental standards and exceptions are

   (1) Where remedial action would pose a clear and present risk of injury to workers or members of the public, notwithstanding reasonable measures to avoid or reduce risk.

(2) Where remedial action, even after all reasonable mitigative measures have been taken, would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected properties, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

(3) Where it is determined that the scenarios or assumptions used to establish the authorized limits do not apply to the property or portion of the property identified, or where more appropriate scenarios or assumptions indicate that other limits are applicable or appropriate for protection of the public and the environment.

(4) Where the cost of remedial action for contaminated soil is unreasonably high relative to long-term benefits and where the residual material does not pose a clear present or future risk after taking necessary control measure. The likelihood that buildings will be erected or that people will spend long periods of time at such a property should be considered in evaluating this risk. Remedial action will generally not be necessary where only minor quantities of residual radioactive material are involved or where residual radioactive material occurs in an inaccessible location at which specific property factors limit its hazard and from which it is difficult or costly to remove. Examples include residual radioactive material under hard-surfaced public roads and sidewalks, around public sewer lines, or in fence-post foundations. A specific property analysis shall be provided to establish that the residual radioactive material would not cause an individual to receive a radiation dose in excess of the basic dose limits stated in paragraph IV.3, and a statement specifying the level of residual radioactive material shall be provided to the appropriate State and/or local agencies for appropriate action, e.g., for inclusion in local land records.

(5) Where there is no feasible remedial action.

8. SOURCES.

a. Basic Dose Limits. Dosimetry model and dose limits are defined in Chapter II of this Order.

b. Generic Guidelines for Residual Radioactive Material. Residual concentrations of radium and thorium in soil are defined in 40 CFR Part 192. Airborne radon decay products are also defined in 40 CFR Part 192, as are guidelines for external gamma radiation. The surface contamination definition is adapted from NRC (1982).

c. Control of Radioactive Wastes and Residues. Interim storage is guided by this Order and DOE 5820.2A. Long-term management is guided by this Order, 40 CFR Part 192, and DOE 5820.2A.

APPENDIX C

POTENTIAL RESPONSE ACTIONS AND TECHNOLOGIES OR ENVIRONMENTAL MEDIA AT THE ST. LOUIS SITE

TABLE C-1

Potential Response Actions and Technologies for Soil/Sludge

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
No action	No action	Not applicable	Not applicable	This is retained as a potential response to provide a baseline for comparison with action alternatives.
Minimize potential exposure to external gamma radiation; minimize potential exposure to radioactive contaminants via ingestion; minimize potential exposure to radioactive contaminants via inhalation; minimize potential bio-uptake of radioactive contaminants; minimize potential migration of radioactive contaminants that could (further) contaminate surface water, groundwater, and other soils/sludges.	Institutional controls	Access restrictions Ownership and deed restrictions Monitoring	Fences and guards Legal titles and deeds Groundwater wells and air, surface water, and soil/sludge samplers	These varied institutional controls are typically not effective in controlling the source or migration of contaminants and are generally used only to support other response actions.

TABLE C-1

(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
Minimize toxicity, mobility, and/or volume of contaminated material (and as for institutional controls)	In situ containment	Surface controls/diversion	Graded contours, swales and berms, and vegetation	Surface controls and capping can limit contaminant mobility and can mitigate potential exposures, bio-uptake and migration (via air, surface water, and groundwater) by attenuating gaseous emissions (e.g., radon) and controlling particulate resuspension, surface water runon and runoff, and precipitation-enhanced percolation and leaching. These processes can be implemented with conventional equipment.
		Capping	Soil (clay) and vegetation or riprap; asphalt or cement; synthetic membrane material; and multilayer, multimedia material	
		Lateral barriers	Slurry wall, grout curtain, and sheet piling	Lateral barriers and bottom sealing can limit contaminant mobility and can mitigate potential exposures by limiting migration to other soils/sludges, groundwater, and surface water (e.g., via groundwater recharge). These processes can be implemented with conventional equipment but are not typically used unless the substrate water content is high.
		Bottom sealing	Grout layer injection and block displacement	

TABLE C-1

(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Removal	Excavation/pumping	Dragline, backhoe, bull-dozer, scraper, and front end loader	Excavation and pumping can limit contaminant mobility and can mitigate potential exposures and bio-uptake by controlling the contaminant source. These technologies can be implemented with conventional equipment.
			Pumping (sludges or slurried soils)	Various pump types, including positive displacement and Moyno (progressing cavity) pumps.
As for in situ containment	Treatment/pretreatment:	Physical:		
	In situ	Dewatering/drying	Solar evaporation, pumping, and gravity drainage trenches	Dewatering/drying can limit the mobility and volume of contaminated materials and mitigate potential exposures, migration and bio-uptake. These processes can be implemented using conventional methods.

TABLE C-1

(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Treatment/pretreatment (cont'd):	Physical (cont'd):		
	In situ (cont'd)	Nonthermal extraction	Soil flushing (water only), using wells and surface application	Nonthermal extraction in situ can reduce the toxicity, mobility, and volume of contaminated soil/sludge and can limit potential exposures, bio-uptake, and migration by controlling the contaminant source. The primary action associated with soil flushing with water is a physical "sweeping" to accelerate contaminant migration by injection or spraying/ponding; hence it is being discussed as a physical technology. Water alone is typically a poor flushing solution, and this process is generally ineffective for complex wastes in soils of high organic content and low permeability.

TABLE C-1

(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Treatment/pretreatment (cont'd)	Physical (cont'd)		
		Thermal destruction	In situ vitrification (ISV), using electrodes	Thermal destruction in situ can reduce the toxicity, mobility, and volume of contaminated soil/sludge and can limit potential exposures, bio-uptake, and migration by controlling the contaminant source. In ISV, an electric current is used to melt the soil/sludge and destroy organic compounds by pyrolysis and combustion; upon cooling, a glassy, durable matrix is formed that incorporates inorganic contaminants (including radio-nuclides) and other nonvolatile compounds. Field-scale demon-stration of ISV has been limited, and it remains in the advanced developmental stage for waste treatment.

TABLE C-1

(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Treatment/pretreatment (cont'd):			
	Following removal	Dewatering/drying	Rotary drum, vacuum, and belt filtration; drying beds; filter press; automatic pressure filtration; gravity thickening; centrifugation; and evaporation	As for dewatering/drying in situ
		Solids separation	Classification (mechanical/non-mechanical); soil sorting, sand sifting (grizzlies) and screening (wet/dry); flotation and gravity concentration/centrifugation; magnetic and paramagnetic separation; and electrostatic separation	Solids separation processes can limit the toxicity, mobility, and volume of contaminated materials and mitigate potential exposures, migration, and bio-uptake. Although certain solids separation processes have been used to extract radionuclides from ores, they are generally ineffective for separating relatively low concentrations of contaminants from soil/sludge. This technology often serves as a pretreatment step for primary treatment processes and is considered developmental for waste treatment applications.

TABLE C-1
(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Treatment/pretreatment (cont'd):	Physical (cont'd)		
	Following removal (cont'd)	Size reduction	Impact crushers, shredders, and tumbling hammer mills	These processes can reduce the size/volume of waste materials, which is often required as a pretreatment step for primary treatment processes (e.g., chemical extraction and thermal destruction processes). Size reduction can be achieved using conventional methods.
		Nonthermal extraction	Soil washing (water only), using a reactor vessel	Nonthermal extraction following removal achieves remedial action objectives in a manner similar to nonthermal extraction in situ. Soil/sludge can be mixed with water in a contact vessel to wash contaminants from the waste matrix, but water alone is typically ineffective as a washing solution.

TABLE C-1

(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Treatment/pretreatment (cont'd):	Physical (cont'd):		
	Following removal (cont'd)	Thermal extraction/destruction	Low-temperature thermal stripping; rotary kiln and fluidized bed incineration; pyrolytic incineration/electric reactor, and high-temperature fluid wall reactor; circulating bed and molten salt combustion; plasma arc torch and infrared (IR) thermal destruction; wet air and supercritical water oxidation; and vitrification (joule-heated ceramic melter)	Thermal treatment following removal achieves remedial action objectives in a manner similar to thermal treatment in situ. The various process options typically produce a solid (e.g., ash, char, or glassy block), liquid (e.g., scrubbing water, brine, or condensate) and gaseous (e.g., volatilized organics and metals and innocuous gases) effluent. Thermal destruction processes are typically used to destroy organics, and while some are commonly used in waste treatment (e.g., incinerators), others are developmental (e.g., IR and supercritical water oxidation) and have been demonstrated only on a pilot scale.

TABLE C-1
(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Treatment/pretreatment (cont'd):	Physical (cont'd):		
	In situ	Soil flushing	Inorganic salts, mineral acids, complexing reagents via surface application and injection/extraction wells	In situ flushing can reduce the toxicity, mobility, and volume of contaminated soil/sludge via desorptive reactions and can limit potential exposures, bio-uptake, and migration by controlling the contaminant source. This technology can be used as an initial treatment step to leach contaminants from a waste matrix. The solubility of radionuclides can be enhanced by solvent application, and the reagent solution can be sprinkled or ponded over the contaminated zone for aggressive treatment. Because this technology is very contaminant-specific and the selection of a suitable flushing fluid is difficult, it is ineffective for complex wastes. Mobile units are available, but full site cleanup has not yet been demonstrated by these processes.

TABLE C-1

(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Treatment/pretreatment (cont'd):			
	In situ	Chemical addition/detoxification	Hydrolysis, redox reactions, neutralization, precipitation, and solidification using drills, augers, and paddles for chemical addition	Chemical detoxification can achieve remedial action objectives in a manner similar to in situ soil flushing via chemical reactions that alter the toxic nature of the contaminants or solidify them to limit mobility; however, in contrast to soil flushing, these reactions can increase the total volume of contaminated material following chemical addition (e.g., for precipitation and solidification processes). Chemical agents can be dispensed through a shaft and mixed via an up/down drill motion or by augers and hydraulically driven paddles; reagents are typically selected for treatment specificity. This technology is developmental for waste treatment applications and must be evaluated on a site-specific basis.

TABLE C-1

(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Treatment/pretreatment (cont'd):	Chemical (cont'd)		
	In-situ (cont'd)	Stabilization/fixation	Lime- and portland cement-based pozzolanic reactions, asphalt-based thermoplastic micro-encapsulation, and catalyzed polymerization using drills, augers, and paddles for chemical introduction	In situ stabilization/ fixation processes can achieve remedial action objectives in a manner similar to in situ chemical detoxification. This technology is typically used to treat soil/sludge contaminated with heavy metals and high molecular weight organics by binding the contaminants in place in an insoluble matrix or in a matrix that minimizes the surface exposed to potential solvents. Field demonstration of this technology in waste treatment applications has been limited.
	Following removal	Contact extraction	Soil washing (non-water), inorganic salts, mineral acids and complexing reagents using a reactor vessel	Chemical extraction following removal achieves remedial action objectives in a manner similar to in situ soil flushing. Various solutions can be used to separate radionuclides from soil/sludge in an agitated reactor vessel.

TABLE C-1

(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Treatment/pretreatment (cont'd):	Chemical (cont'd):		
	Following removal (cont'd)	Stabilization/fixation	As for the in situ application, but using a reactor vessel	Process is similar to the in situ application, except that effectiveness is less constrained because various pretreatment options are available (e.g., dewatering and crushing). Following implementation, the wastes could be replaced in the area from which they were removed. This technology has been demonstrated for low-level radioactive waste treatment applications.
	Temporary storage	Onsite or offsite facility	Engineered structure	Temporary storage can reduce the mobility and volume of contaminated materials and can limit potential exposures, bio-uptake, and migration by controlling the contaminant source. This option requires the engineering of a storage facility and is implemented as an interim measure while a permanent remedy is developed. Constraints include technical (engineering) and socio-political (acceptability) issues.

TABLE C-1

(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
	Disposal	Onsite or offsite facility	Engineered structure (on land)	Disposal can reduce the mobility and volume of contaminated materials and can limit potential exposures, bio-uptake, and migration by controlling the contaminant source. (Disposal often follows the treatment of contaminated materials, so toxicity reduction is often inherent in the overall management scheme.) This option requires the engineering of a disposal facility. In addition to engineering requirements, constraints include issues such as site suitability; transportation, including routes, risks, and costs (for the off-site options); and regulator/community acceptance.

Table C-2

Potential Response Actions and Technologies for Surface Water

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
No action	No action	Not applicable	Not applicable	This is retained as a potential response to provide a baseline for comparison with action alternatives.
As for soil/sludge under institutional controls	Institutional controls	Access restrictions Ownership and deed restrictions Monitoring	Fences and guards Legal titles and deeds Groundwater wells and air, surface water, and soil/sludge samplers	These varied institutional controls are typically not effective in controlling the source or migration of contaminants and are generally used only to support other response actions.
Minimize toxicity, mobility, and/or volume of contaminated material (and as for institutional controls)	In situ containment	Surface controls/diversions	Graded contours, swales, dikes, and berms	Surface controls can limit contaminant mobility and can mitigate potential exposures, bio-uptake, and migration by controlling surface water run-on and run-off. These processes can be implemented with conventional equipment.

Table C-2
(continued)

2 of 8

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
		Lateral barriers	Grout layer injection and block displacement	Lateral barriers and bottom sealing can limit contaminant mobility and can mitigate potential exposures by limiting migration to underlying soils, surface water, and groundwater. These processes can be implemented with conventional equipment, but field applications can be constrained by site-specific geologic conditions.
		Bottom sealing	Slurry wall, grout curtain, and sheet piling	
As for in situ containment	Removal/collection	Interception and pumping	Interceptor channels and dynamic (centrifugal), reciprocating, and positive displacement pumps	Runoff interception and pumping can limit the toxicity, mobility, and volume of contaminated material at the surface water location, thereby mitigating potential exposures, bio-uptake, and migration by controlling the contaminant source. This technology can be implemented with conventional equipment and is typically followed by a treatment scheme to reduce contaminant toxicity, mobility, and volume in the collected water.

Table C-2
(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Removal/collection (cont'd):	Skimming and "sinker" collection	Floating boom and siphon dam	These in situ processes can reduce the toxicity, mobility, and volume of contaminated surface water and can limit potential exposures, bio-uptake, and migration by controlling the contaminant source. They can be implemented with conventional methods and are typically used to remove floating oils and dense ("sinking") contaminants from surface water (primarily streams).
As for in situ containment	Treatment/pretreatment: In situ	Physical: Nonthermal extraction	Density separation (clarification and flotation), and flocculation (via agitation)	These in situ processes can reduce the toxicity, mobility, volume of contaminated surface uptake, and contaminant migration by controlling the contaminant source. Such methods include enhanced sedimentation (using a settling agent and air bubbling), and mixing with blades and air. They can be implemented with conventional methods.

Table C-2
(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
	Treatment/pretreatment (cont'd):	Physical (cont'd)		
	In situ (cont'd)	Thermal extraction	Solar evaporation	This thermal process can achieve remedial action objectives in a manner similar to nonthermal extraction in situ. Natural irradiation can be enhanced with covers and condensate collection to expedite treatment, and although this process can be implemented with conventional equipment, its application is constrained by site-specific climatic conditions.
	Following removal	Nonthermal extraction	Density separation (centrifugation), flocculation, adsorption, osmosis, reverse osmosis/ ultrafiltration, electrodialysis	These nonthermal extraction processes following removal can achieve remedial action objectives in a manner similar to nonthermal extraction in situ, but with fewer constraints and greater control of reactions and products. The processes can generally be implemented with conventional equipment, and many are used to treat suspended solids. Certain processes have been used in industrial wastewater treatment, but their demonstration in low-level radioactive waste treatment has been limited.

Table C-2
(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Treatment/pretreatment (cont'd):	Chemical:		
	In situ	Chemical addition	Lime softening, alumina precipitation	Chemical addition can reduce the toxicity, mobility, and volume of contaminated surface water and can limit potential exposures, bio-uptake, and contaminant migration by controlling the contaminant source. This is achieved via chemical reactions that alter the toxic and/or physical nature of the contaminants. Chemical reagents can be mixed into surface water by mechanical means (e.g., paddles and blades) or aeration. These processes can be implemented with conventional methods to treat radioactive wastes and are common in wastewater treatment applications (although much more so following removal than in situ); their application for hazardous waste treatment has been limited.

Table C-2
(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Treatment/pretreatment (cont'd):	Chemical (cont'd):		
	In situ (cont'd)	Chemical addition	As for the in situ application, with additional processes (e.g., ion exchange and adsorption beds) and using a reactor vessel	The reaction system is similar to the in situ application, but it can be better controlled and process effectiveness can be optimized. Chemical addition can treat low-level radioactive contaminants and can be implemented with conventional methods. Its use is common in wastewater treatment applications, but its application for hazardous waste treatment has been limited.

Table C-2
(continued)

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Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Disposal (cont'd)	Onsite	Groundwater injection or discharge on land or to other surface water	Onsite disposal can reduce the toxicity of contaminated surface water (by dilution) following direct discharge and can limit mobility, volume, potential exposures, bio-uptake, and migration at the original location by controlling the contaminant source. Surface water can be directly injected into the ground or discharged on land (e.g., via spraying) or to another surface water onsite (e.g., by pipe or gravity drainage) following collection, but it is not typically released before being treated. When used in conjunction with treatment, disposal can reduce the toxicity, mobility, and volume of contaminated surface water and limit overall exposures, bio-uptake, and migration.

Table C-2
(continued)

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Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
	Disposal (cont'd)	Offsite	Groundwater injection or discharge on land, to publicly owned treatment works (POTW), or to other surface water	Offsite disposal can achieve remedial action objectives in a manner similar to onsite disposal, with an additional option (i.e., piping to a POTW). This option must often be preceded by some type of treatment and requires permission from the operator. As for onsite disposal, surface water is not typically disposed of directly offsite; rather, it is often released only after being treated.

TABLE C-3

Potential Response Actions and Technologies for Groundwater

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
No action	No action	Not applicable	Not applicable	This is retained as a potential response to provide a baseline for comparison with action alternatives.
As for soil/sludge under institutional controls	Institutional controls	Access restrictions Ownership and deed restrictions Monitoring (e.g., of natural attenuation)	Fences at well/point of recharge Legal titles and deeds/ decrees Groundwater wells and air and surface water samplers	These varied institutional controls are typically not effective in controlling the source or migration of contaminants and are generally used only to support other response actions. An alternative water supply is typically an interim measure used to ensure human health while a permanent remedy is developed.
		Alternative water supply	Piped/transported water or water from a separate (uncontaminated) source (groundwater aquifer or surface water/municipal supply)	These varied institutional controls are typically not effective in controlling the source or migration of contaminants and are generally used only to support other response actions. An alternative water supply is typically an interim measure used to ensure human health while a permanent remedy is developed.

TABLE C-3
(continued)

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
Minimize toxicity, mobility, and/or volume of contaminated material (and as for institutional controls)	In situ containment	Lateral barriers	Slurry wall, grout curtain, and sheet piling	Lateral barriers can limit contaminant mobility and can mitigate potential exposures by limiting migration (e.g., to uncontaminated groundwater and to surface water via recharge). These processes can be implemented with conventional equipment, but their effectiveness is constrained by site-specific hydrogeological conditions. (Note that insofar as surface controls can limit contaminant migration to groundwater, they may be addressed for groundwater control; see discussion of surface controls for soil/sludge.)
		Bottom sealing	Grout layer injection and block displacement	Bottom sealing can achieve remedial action objectives in a manner similar to lateral barriers under similar constraints. This technology may be useful for containment of lenses or perched aquifers but is not typically effective for deep groundwater systems.

TABLE C-3
(continued)

3 of 4

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Removal/collection	Interception and pumping	Subsurface drains and interceptor trenches; and well points, suction wells, ejection wells, and deep wells	Groundwater removal by pumps and trenches can limit the toxicity, mobility, and volume of contaminated material at the location, thereby mitigating potential exposures, bio-uptake, and migration by controlling the contaminant source. This technology can be implemented with conventional equipment and is typically followed by a treatment scheme to reduce contaminant toxicity, mobility, and volume in the collected water.
As for in situ containment	Treatment/pretreatment: In situ	Physical: Extraction	Air/stream stripping	This process can reduce the toxicity, mobility, and volume of contaminants in groundwater and can limit potential exposures, bio-uptake, and migration by controlling the contaminant source. Insofar as many other treatment systems also involve groundwater capture (and upgradient reinjection), see discussion of in situ treatment for soil/sludge for related information.
	Following removal	Nonthermal extraction	As for surface water following removal	The process is the same as for surface water following removal.
		Thermal extraction/ destruction	As for surface water following removal, and solar evaporation (see discussion for surface impoundment following removal)	The process is the same as for surface water following removal.

TABLE C-3
(continued)

4 of 4

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
	Treatment/pretreatment (cont'd):	Chemical:		
	In situ	Chemical injection	As for chemical addition for surface water in situ	The process is similar to chemical addition for surface water in situ, except that mixing cannot be enhanced by mechanical means.
As for in situ containment		Contact reaction system	Permeable treatment beds, with pumps or French drain systems	Permeable treatment beds can reduce the toxicity, mobility, and volume of contaminated groundwater and can limit potential exposures, bio-uptake, and migration by controlling the contaminant source. This process is used in conjunction with collection (e.g., pump/drain). Bed media can range from crushed limestone and activated carbon to glauconitic green sands and synthetic ion exchange resins. Implementation of this process is constrained by site-specific hydrogeologic conditions.
	Following removal	Extraction	As for surface water following removal	The process is the same as for surface water following removal.
As for in situ containment		Chemical addition	As for surface water following removal	The process is the same as for surface water following removal.
As for in situ containment	Disposal	Onsite	Reinjection or discharge on land or to surface water	The process is the same as for surface water following removal.
		Offsite	Reinjection or discharge on land, to POTW, or to surface water	The process is the same as for surface water following removal.

TABLE C-4

Potential Response Actions and Technologies for Structural Debris

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
No action	No action	Not applicable	Not applicable	This is retained as a potential response to provide a baseline for comparison with action alternatives.
As for soil/sludge under institutional controls	Institutional controls	Access restrictions	Fences and guards	These varied institutional controls are typically not effective in controlling the source or migration of contaminants and are generally used only to support other response actions.
		Ownership and deed restrictions	Legal titles and deeds	
		Monitoring	Groundwater wells and air, surface water, and soil/sludge samplers	
Minimize toxicity, mobility, and/or volume of contaminated material (and as for institutional controls)	In situ containment	Release controls	Surface sprays (sealer paints and emulsions)	Release controls can limit contaminant mobility and can mitigate potential exposures, bio-uptake, and migration by controlling the contaminant source. These processes can be implemented with conventional equipment.

TABLE C-4
(continued)

2 of 3

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Removal	Decontamination	Aggressive vacuuming, solvent wiping, foam/emulsion application, steam and high-pressure water washing, and carbon dioxide pellet and abrasive grit blasting	Decontamination processes can reduce the toxicity, mobility, and volume of contaminated structures (via transfer to the decontamination residue) and can limit potential exposures, bio-uptake, and migration by controlling the contaminant source. Decontamination can be used to remove organics and inorganics [including removable (i.e., non-fixed) radionuclides] from structural surfaces. These processes can be implemented with conventional equipment.
As for in situ containment	Treatment/pretreatment: In situ	Demolition	Wrecking equipment (balls, cranes)	This process can reduce the size/volume of contaminated structures and can be implemented with conventional equipment.
		Decontamination/ extraction	Vacuuming, wiping, washing, and blasting	This process is the same as for decontamination under removal (because these processes can be considered under both removal and treatment, they are listed under both response actions).
	Following removal	Size reduction	Impact crushers, shredders, and tumbling and hammer mills	This process is the same as for demolition.

TABLE C-4
(continued)

3 of 3

Remedial Action Objectives	General Response Actions	Potential Technology Types	Potential Process Options	Comments
As for in situ containment	Treatment/pretreatment (cont'd):	Physical (cont'd):		
	Following removal (cont'd):	Decontamination/ extraction	As for the in situ application	This process is the same as for the in situ application.
		Thermal treatment	Incineration and melting/thermal destruction in kilns and furnaces	Thermal treatment processes can reduce the toxicity, mobility, and volume of contaminated structural debris and can limit potential exposures, bio-uptake, and migration by controlling the contaminant source. These processes can destroy organics and retain inorganics in the solid residue. Although certain thermal processes have been used in industrial applications, their demonstration for structural debris contaminated with hazardous waste has been limited.
		Chemical:		
	In situ	Decontamination/ extraction	Solvent washing and foam/emulsion application	This process is the same as for physical decontamination in situ.
	Following removal	Decontamination/ extraction	Solvent washing, foam/ emulsion application, and chemical (e.g., acid) bath extraction	This process is the same as for physical decontamination in situ.
As for in situ containment	Temporary storage	Onsite or offsite facility	Engineered structure	This process is the same as for temporary storage of soil/sludge.
As for in situ containment	Disposal	Onsite or offsite	Engineered structure (on land) or ocean disposal	This process is the same as for disposal of soil/sludge.

APPENDIX D

SOURCE TERM ANALYSIS SUMMARY FOR THE ST. LOUIS SITE

APPENDIX D

SOURCE TERM ANALYSIS SUMMARY FOR THE ST. LOUIS SITE

INTRODUCTION

To support the development of the baseline risk assessment for the St. Louis, Missouri, FUSRAP properties, radiological analyses of soil samples were conducted for the St. Louis Downtown Site (SLDS), the St. Louis Airport Site (SLAPS), and the Latty Avenue Properties. The analytical results indicate the maximum and average radionuclide concentrations at each property. The soil samples collected were analyzed for uranium-238, uranium-235, uranium-234, thorium-232, thorium-230, thorium-227, radium-228, radium-226, radium-224, lead-210, polonium-210, and actinium-227. Protactinium-231 concentrations were calculated based on actinium-227 and thorium-227 values.

METHODOLOGY

At SLDS, each of the seven plants was treated as an individual unit because a different uranium processing step was performed in each plant. Figure 1 shows SLDS, the seven units, and the borehole locations. To determine the maximum radionuclide concentrations for each of the seven units, the soil sample increment for each unit exhibiting the highest count rate during gamma logging of the boreholes was analyzed for the radionuclides listed above. To determine the average radionuclide concentration for each unit, 10 percent of the boreholes (but no fewer than four boreholes) from each unit were selected. The soil samples from each selected borehole were composited by taking equal aliquots of soil, ranging from 15 to 60 g, from each depth region within the borehole. These aliquots were composited and mixed down to 100 mesh, and one sample was pulled from this composite to determine the average radionuclide concentration for each unit.

SLAPS was divided into five units based on historical use of the property; different types of residues and wastes from uranium processing at SLDS had been stored in different areas at SLAPS. Figure 2 shows borehole locations at SLAPS. The maximum and average

radionuclide concentrations for each unit were determined in the same manner as described for SLDS.

The Latty Avenue Properties, which include the Hazelwood Interim Storage Site (HISS) and Futura Coatings, Inc., are considered one unit. The maximum and average concentrations of each radionuclide were determined in the same manner as described for SLDS. Borehole locations at HISS are shown in Figure 3; Figure 4 shows the sampling locations at Futura.

RESULTS

The results of the characterization activities are reported by property on the following pages. The results for each unit are broken down into decay chains for both the average and maximum radionuclide concentrations. Hypotheses based upon analytical data and historical metallurgical reviews of existing documentation are provided to explain the disequilibrium of radionuclides found over the individual properties. A summary of the results is provided on pages D-26 and D-27.

The results indicate equilibrium on some units and disequilibrium on others. The disequilibrium is usually indicated by elevated thorium-230 or elevated uranium concentrations in relation to the other radionuclides in the decay chains. The results of this study are consistent with previous characterization efforts. In these results, the activity of protactinium-231 is not measured directly but is estimated from the decay products actinium-227 and thorium-227.

The activity of protactinium-231, with a half-life of 32,500 years can be calculated from its immediate daughter, actinium-227 with a half-life of 21.6 years. After two half-lives of the daughter, or 43.2 years, the activity of the daughter would be 75 percent of the parent's activity + 25 percent of the original activity of the daughter.

The activity of protactinium-231 may be underestimated by 25 percent if there were absolutely no actinium-227, an unlikely possibility, in the original material or it may be

overestimated by 100 percent if the actinium-227 were five times as great as the protactinium-231. The amount may be overestimated by a great deal, depending on the original daughter activity, but it cannot be underestimated by more than 25 percent. Overestimating the amount errs on the conservative side.

The same argument carries through to the estimation of protactinium-231 from the activity of thorium-227, the immediate daughter of actinium-227. Thorium-227 has a half-life of 18.2 days and may be assumed to be in equilibrium with actinium-227. The errors in estimating protactinium-231 from the thorium-227 activity are, therefore, the same as estimating the protactinium-231 activity from actinium-227.

Plant 1 at SLDS. Plant 1 was the main plant and was used as the refinery for uranium ore feed and pitchblende from 1942 to 1945 and released in 1951.

Based on average radionuclide concentrations in Plant 1, all components of the three decay chains seem to be in equilibrium except for thorium-230, which is found in concentrations approximately 6 to 7 times greater than the average concentrations of other radionuclides in the uranium-238 decay chain. This probably results from some type of preferential migration or deposition of wastes with high thorium content. Analysis of the composite sample constituents showed that borehole 116DT0966 at the 4- to 6-ft depth contains a thorium-230 concentration of 230 pCi/g, and borehole 116DT1481 at the 0.5- to 2-ft depth has a thorium-230 concentration of 91 pCi/g. The thorium-230 concentrations in the other soil samples are all less than 39 pCi/g.

The maximum concentration results indicate that the uranium isotopes in both the uranium-238 and uranium-235 chains are out of equilibrium, indicating an excess of some type of uranium product. These results are not indicative of concentrations at the entire plant but indicate the most conservative case at Plant 1. All other radionuclides in all other decay chains are near equilibrium.

Average and maximum radionuclide concentrations are provided in Table 1.

Plant 2 at SLDS. Plant 2 was used for the digestion and treatment of uranium ore feeds, ether extraction of pitchblende liquor, denitrification, hydrogen reduction, and temporary storage of residues. This plant was released in 1951.

Based on average radionuclide concentrations in Plant 2, the thorium-232 decay chain seems to be in equilibrium. The uranium-238 and actinium decay chains indicate greater concentrations of uranium isotopes than other radionuclides. In the uranium-238 chain, a larger concentration of thorium-230 in relation to other radionuclides is also noted, which could have resulted from hydroxide coprecipitation of thorium and uranium.

The maximum concentration results for radionuclides at Plant 2 indicate higher concentrations of uranium-238, uranium-234, and thorium-232 than of the other radionuclides in the three decay chains. This also could represent some type of hydroxide coprecipitation of thorium and uranium or an excess of uranium product.

Average and maximum concentrations for the three decay chains are shown in Table 2.

Plant 5 at SLDS. The average concentrations of radionuclides in the uranium-238 decay series show slight excesses of uranium-238 and uranium-234 concentrations, possibly due to some type of uranium product in the area. The radionuclides in the thorium-232 and actinium decay chains are in equilibrium.

The maximum concentrations of radionuclides at Plant 5 suggest that uranium-238 and uranium-234 have been extracted and removed for use in production, while the remaining radionuclides were perhaps concentrated in the waste stream and remained on site. The thorium-232 decay chain indicates the separation of thorium and radium, with the radium probably having been removed from the plant. The uranium-235 chain shows that equilibrium conditions exist. Because measurements from gamma logging were used in choosing samples to determine average and maximum radionuclide concentrations, the average concentration of a particular radionuclide is sometimes greater than the concentration of the same radionuclide in a borehole chosen to be sampled for the maximum value. This

occurred at Plant 5 at SLDS and Unit 2 at SLAPS. The average and maximum radionuclide concentrations found at Plant 5 are given in Table 3.

Plant 6 at SLDS. During operation, Plant 6 (which replaced Plant 1) was used for processing pitchblende ore, producing uranium oxide and a uranium nitrate product, conducting solvent extraction procedures and denitrification to produce uranium oxide, and forming uranium tetrafluoride.

The average radionuclide concentrations for Plant 6 indicate that the uranium-238 chain is not in equilibrium, as shown by higher concentrations of uranium-238 and uranium-234 relative to other radionuclides in the decay chain. The results could reflect hydroxide coprecipitation of thorium and uranium. The thorium-232 chain shows relative equilibrium. Results for the uranium-235 chain are similar to those for the uranium-238 decay series. There were higher concentrations of uranium-235 than of other radionuclides in the decay chain, indicating that the radionuclide was separated or that uranium product was concentrated on or near the plant.

The maximum radionuclide concentrations of uranium (shown clearly in both the uranium-238 and uranium-235 decay series) were higher than those of other radionuclides, indicating that some type of preferential separation had occurred. Table 4 provides the radionuclide concentrations for Plant 6.

Plant 7 at SLDS. Plant 7 was used to produce green salt and reactor cores and to remove metallic uranium from slag by wet grinding. It is currently used for storage.

All average radionuclide concentrations in the uranium-238, thorium-232, and uranium-235 decay chains seem to be in equilibrium. The maximum radionuclide concentrations for uranium isotopes and their daughters may be in disequilibrium. The uranium-238 chain seems to indicate that uranium-234 and uranium-238 were preferentially removed with thorium-230. The same situation appears in the uranium-235 chain, which shows higher concentrations of protactinium-231, actinium-227, and thorium-227 than of

uranium-235. The thorium-232 chain indicates equilibrium. See Table 5 for the average and maximum radionuclide concentrations.

Plant 7E at SLDS. The average radionuclide concentrations found in Plant 7E show disequilibrium in the uranium-238 chain. The thorium-230 concentration is higher than the other radioisotopes in the chain, possibly because of preferential migration or deposition of waste with high thorium content.

The maximum radionuclide concentrations are similar to average concentrations—i.e., much higher concentrations of thorium-230 occur in the uranium-238 chain, indicating possible migration. The thorium-232 chain shows separation of radium and thorium isotopes. Average and maximum concentrations of radionuclides at Plant 7E are given in Table 6.

Plant 10 at SLDS. The average concentrations of radionuclides found in Plant 10 indicate preferential migration or deposition of waste with high thorium content. Thorium-230 concentrations in the uranium-238 chain are approximately ten times greater than concentrations of other radionuclides in the chain.

The maximum radionuclide concentrations are similar to the average concentrations. All constituents of the thorium-232 and uranium-235 chains seem to be in or near equilibrium. Table 7 provides the average and maximum radionuclide concentrations for Plant 10.

Unit 1 at SLAPS. The average radionuclide concentrations at Unit 1 at SLAPS suggest that concentrations of thorium isotopes in the uranium-238, thorium-232, and uranium-235 chains are not in equilibrium. This could indicate preferential migration or preferential separation of thorium from other radionuclides. See Table 8 for radionuclide concentrations at Unit 1.

Unit 2 at SLAPS. The average radionuclide concentrations measured at Unit 2 at SLAPS reveal that all radioisotopes are in disequilibrium. Thorium-230 concentrations in uranium-238 chain greatly exceed concentrations of other radionuclides in the chain. The

thorium-232 chain also shows thorium concentrations to be approximately six times greater than those of radium isotopes; this could be an indication that preferential migration occurred, that thorium compounds were preferentially separated, or that the compounds were left behind as a waste stream.

The maximum radionuclide concentrations in Unit 2 indicate that uranium isotopes had been concentrated and removed, leaving behind the daughters. This is shown clearly in the uranium-238 and uranium-235 chains. Table 9 provides the average and maximum concentrations of radionuclides.

Unit 3 at SLAPS. At Unit 3 at SLAPS, the average radionuclide concentrations indicate that all components are in equilibrium except thorium-230 in the uranium-238 chain and thorium in the thorium-232 chain. This may have resulted from preferential migration or a concentrated volume of thorium as a residual from uranium processing. The average radionuclide concentrations are shown in Table 10.

Unit 4 at SLAPS. The average and maximum radionuclide concentrations measured at Unit 4 at SLAPS reveal that thorium-230, thorium-232, and thorium-228 in the uranium-238 and thorium-232 chains, respectively, are out of equilibrium. Analytical results show that thorium constituents may have been separated from the remaining radionuclides and deposited by some means in this area, or that preferential migration has occurred. See Table 11 for average and maximum radionuclide concentrations.

Unit 5 at SLAPS. The average radionuclide concentrations found in Unit 5 at SLAPS indicate that uranium-238, uranium-234, and thorium-230 in the uranium-238 chain are out of equilibrium. Analytical results suggest that uranium and thorium constituents were separated for further purification or product production, while the remaining radionuclides were removed. The above results could also be due to deposition of an acid waste stream. Average radionuclide concentrations are provided in Table 12.

The maximum and average radionuclide concentrations at HISS and Futura indicate that thorium isotopes are out of equilibrium, which may have resulted from preferential migration

or the deposition of waste product resulting from the extraction of uranium. Table 13 lists the average and maximum radionuclide concentrations at HISS and Futura. Table 14 summarizes the source term analyses.

FIGURES FOR APPENDIX D

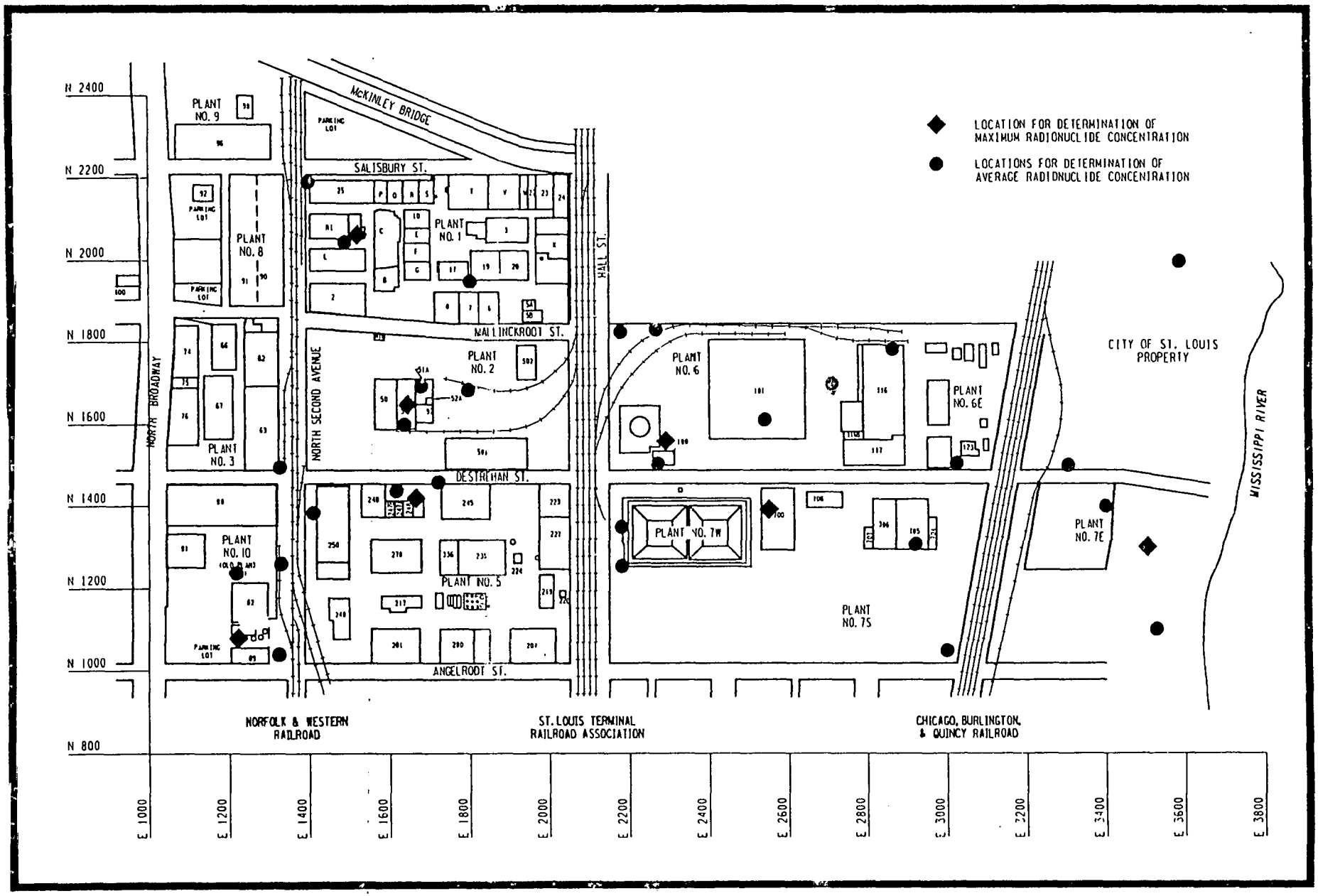

FIGURE 1 SAMPLING LOCATIONS AT SLDS

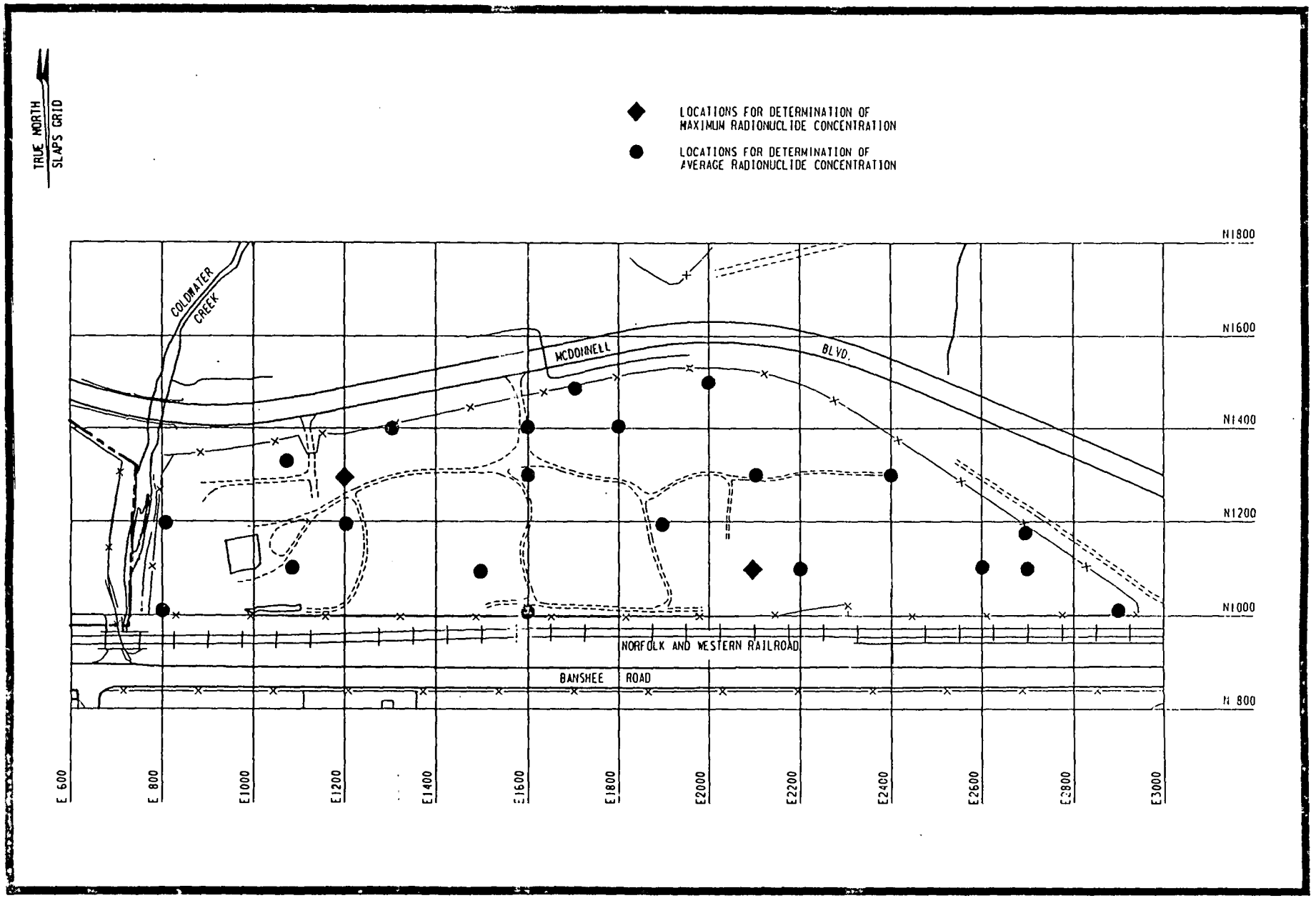

FIGURE 2 SAMPLING LOCATIONS AT SLAPS

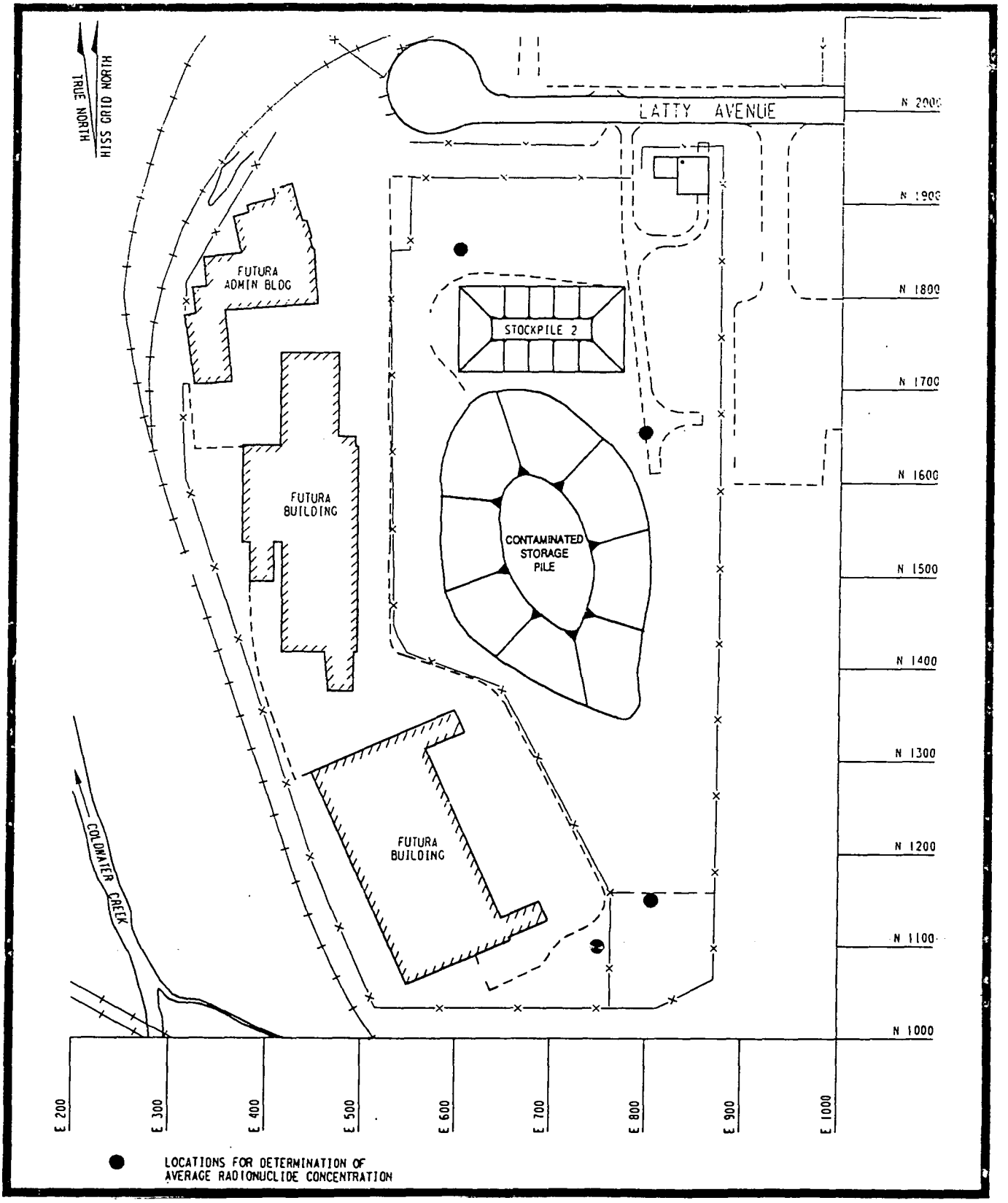

FIGURE 3 SAMPLING LOCATIONS AT HISS

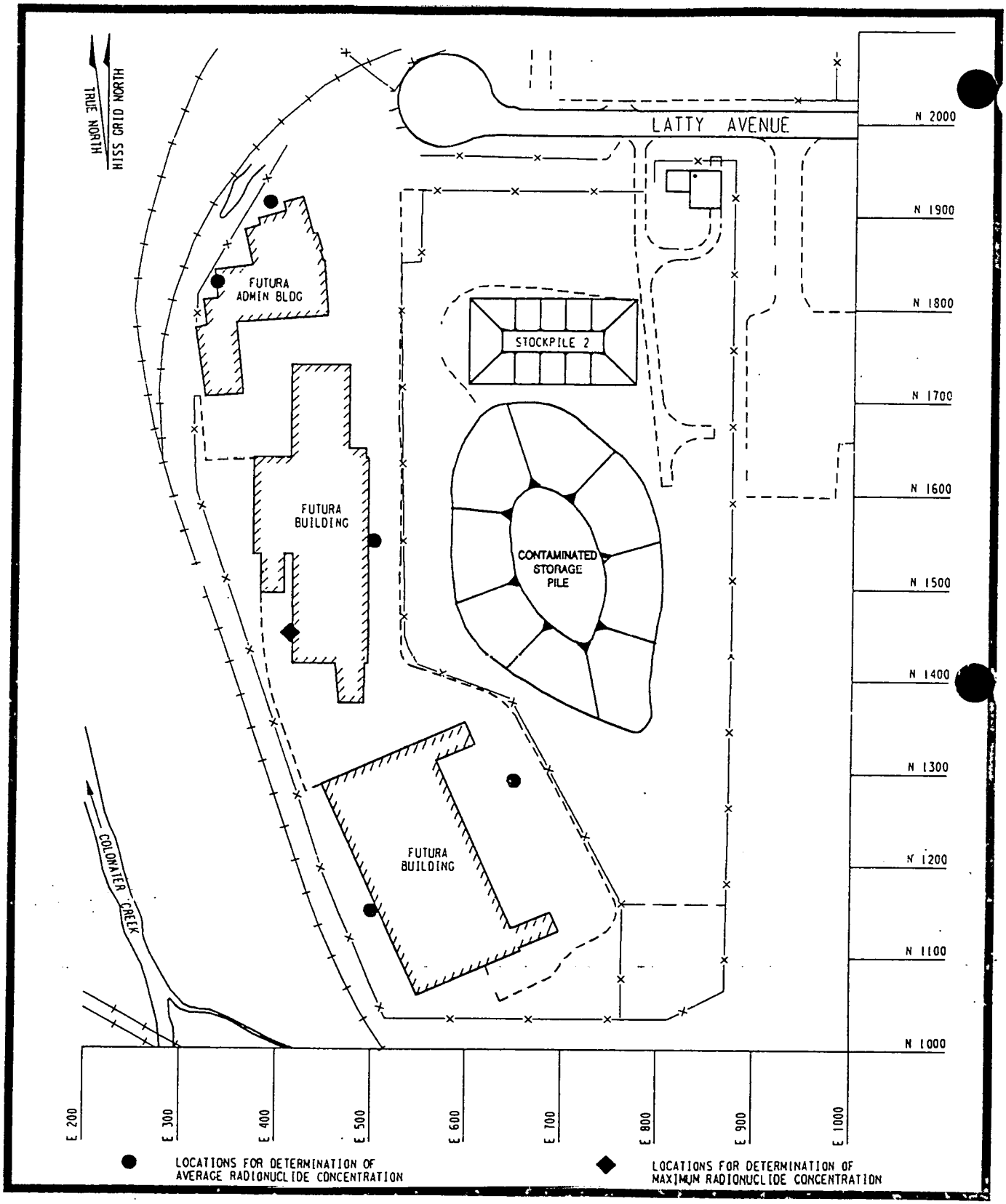

FIGURE 4 SAMPLING LOCATIONS AT FUTURA

TABLES FOR APPENDIX D

Table 1

Analytical Results for Plant 1 At SLDS[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	32.0	2,000.0
U-234	32.0	2,100.0
Th-230	210.0	320.0
Ra-226	22.0	140.0
Pb-210	23.0	470.0
Po-210	17.0	310.0
Th-232 Decay Chain		
Th-232	1.8	0.8
Ra-228	1.3	5.0
Th-228	1.7	1.0
Ra-224	1.4	3.6
U-235 Decay Chain		
U-235	1.5	150.0
Pa-231	3.0[b]	39.0[c]
Ac-227	3.0	15.0
Th-227	6.5	39.0

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]Based on the Ac-227 value.

[c]Based on the Th-227 Value.

Table 2

Analytical Results for Plant 2 at SLDS[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	260.0	6,400.0
U-234	300.0	9,300.0
Th-230	70.0	7,800.0
Ra-226	2.5	280.0
Pb-210	4.3	290.0
Po-210	3.0	260.0
Th-232 Decay Chain		
Th-232	1.0	6.0
Ra-228	0.4	<5.0
Th-228	0.9	6.0
Ra-224	0.9	<5.0
U-235 Decay Chain		
U-235	25.0	630.0
Pa-231	<2.0[b]	540.0[c]
Ac-227	<2.0	490.0
Th-227	2.3	540.0

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]Based on ingrowth calculations from 1940 and Ac-227.

[c]Based on the Th-227 value.

Table 3

Analytical Results for Plant 5 at SLDS[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	48.0	13.0
U-234	51.0	13.0
Th-230	33.0	33.0
Ra-226	22.0	50.0
Pb-210	22.0	44.0
Po-210	13.0	46.0
Th-232 Decay Chain		
Th-232	2.3	4.6
Ra-228	2.5	< 1.0
Th-228	3.3	4.9
Ra-224	2.6	1.3
U-235 Decay Chain		
U-235	1.9	1.0
Pa-231	1.6[b]	1.0[c]
Ac-227	< 2.0	< 1.0
Th-227	1.3	0.3

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]Based on the mean of U-235 and Th-227 (in equilibrium).

[c]Based on the Ac-227 value.

Table 4

Analytical Results for Plant 6 at SLDS[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	260.0	2,500.0
U-234	290.0	2,700.0
Th-230	77.0	39.0
Ra-226	29.0	3.6
Pb-210	46.0	12.0
Po-210	28.0	5.1
Th-232 Decay Chain		
Th-232	0.8	1.1
Ra-228	1.0	<5.0
Th-228	0.8	1.5
Ra 224	1.0	<5.0
U-235 Decay Chain		
U-235	13.0	190.0
Pa-231	4.0[b]	1.90[c]
Ac-227	4.0	<8.0
Th-227	2.4	1.2

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]Based on the Ac-227 value.

[c]Based on the ingrowth calculations.

Table 5

Analytical Results for Plant 7 at SLDS[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	27.0	150.0
U-234	29.0	160.0
Th-230	33.0	260.0
Ra-226	26.0	530.0
Pb-210	33.0	480.0
Po-210	26.0	530.0
Th-232 Decay Chain		
Th-232	1.0	1.3
Ra-228	<1.0	<2.0
Th-228	1.0	0.9
Ra-224	1.5	<2.0
U-235 Decay Chain		
U-235	1.2	5.9
Pa-231	1.4[b]	19.0[c]
Ac-227	<2.0	19.0
Th-227	1.6	18.0

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]Based on mean of U-235 and Th-227 (in equilibrium).

[c]Based on the Ac-227.

Table 6

Analytical Results for Plant 7E at SLDS[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	8.6	15.0
U-234	9.0	14.0
Th-230	77.0	170.0
Ra-226	2.1	4.4
Pb-210	3.8	6.0
Po-210	3.5	4.1
Th-232 Decay Chain		
Th-232	1.8	4.1
Ra-228	0.7	2.8
Th-228	1.7	10.0
Ra-224	1.3	2.4
U-235 Decay Chain		
U-235	0.6	0.5
Pa-231	<2.0[b]	4.0[c]
Ac-227	<2.0	<4.0
Th-227	2.6	3.9

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]Based on the Ac-227 value.

[c]Based on the Ac-227 value.

Table 7

Analytical Results for Plant 10 at SLDS[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	23.0	18.0
U-234	24.0	19.0
Th-230	280.0	82.0
Ra-226	5.4	2.8
Pb-210	3.2	6.9
Po-210	4.2	3.2
Th-232 Decay Chain		
Th-232	1.0	1.1
Ra-228	0.8	4.0
Th-228	1.0	1.0
Ra-224	0.5	2.1
U-235 Decay Chain		
U-235	1.0	0.8
Pa-231	2.0[b]	3.0[c]
Ac-227	<3.0	<3.0
Th-227	2.9	1.0

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]Based on the mean of U-235 and Th-227 (in equilibrium).

[c]Based on the Ac-227 value.

Table 8

Analytical Results for Unit 1 at SLAPS[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	53.0	NA[b]
U-234	53.0	NA
Th-230	2,600.0	NA
Ra-226	23.0	NA
Pb-210	37.0	NA
Po-210	29.0	NA
Th-232 Decay Chain		
Th-232	5.8	NA
Ra-228	0.6	NA
Th-228	5.7	NA
Ra-224	0.8	NA
U-235 Decay Chain		
U-235	2.2	NA
Pa-231	8.0[c]	NA
Ac-227	8.0	NA
Th-227	13.0	NA

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]NA = no sample was chosen to determine the maximum radionuclide concentrations in this unit.

[c]Based on the Ac-227 value.

Table 9

Analytical Results for Unit 2 at SLAPS[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	45.0	110.0
U-234	46.0	110.0
Th-230	3,100.0	800.0
Ra-226	24.0	480.0
Pb-210	44.0	770.0
Po-210	32.0	490.0
Th-232 Decay Chain		
Th-232	6.1	3.5
Ra-228	0.7	<5.0
Th-228	4.3	3.0
Ra-224	0.9	<5.0
U-235 Decay Chain		
U-235	1.8	4.3
Pa-231	16.0[b]	110.0[b]
Ac-227	17.0	110.0
Th-227	15.0	82.0

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]Based on the Ac-227 value.

Table 10

Analytical Results for Unit 3 at SLAPS[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	18.0	NA[b]
U-234	19.0	NA
Th-230	6,800.0	NA
Ra-226	39.0	NA
Pb-210	106.0	NA
Po-210	66.0	NA
Th-232 Decay Chain		
Th-232	3.2	NA
Ra-228	2.5	NA
Th-228	3.2	NA
Ra-224	2.8	NA
U-235 Decay Chain		
U-235	1.0	NA
Pa-231	58.0[c]	NA
Ac-227	58.0	NA
Th-227	28.0	NA

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]NA = No samples were chosen to determine the maximum radionuclide concentrations at the unit.

[c]Based on the Ac-227 value.

Table 11

Analytical Results for Unit 4 At SLAPS[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	9.0	1,500.0
U-234	9.0	1,900.0
Th-230	490.0	44,000.0
Ra-226	14.0	1,200.0
Pb-210	9.0	1,300.0
Po-210	8.2	130.0
Th-232 Decay Chain		
Th-232	3.6	28.0
Ra-228	1.1	< 8.0
Th-228	2.7	28.0
Ra-224	0.7	< 8.0
U-235 Decay Chain		
U-235	0.4	300.0
Pa-231	8.0[b]	300.0
Ac-227	8.0	300.0
Th-227	6.1	190.0

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]Based on the Ac-227 value.

Table 12

Analytical Results for Unit 5 at SLAPS[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	53.0	NA[b]
U-234	54.0	NA
Th-230	1,300.0	NA
Ra-226	10.0	NA
Pb-210	15.0	NA
Po-210	12.0	NA
Th-232 Decay Chain		
Th-232	3.9	NA
Ra-228	0.3	NA
Th-228	3.2	NA
Ra-224	<0.6	NA
U-235 Decay Chain		
U-235	2.1	NA
Pa-231	21.0[c]	NA
Ac-227	15.0	NA
Th-227	21.0	NA

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]NA = No samples were chosen to determine the maximum radionuclide concentrations at this unit.

[c]Based on the Th-227 value.

Table 13

Analytical Results for HISS and Futura[a]

Radionuclide	Concentration (pCi/g) Average	Maximum
U-238 Decay Chain		
U-238	370.0	820.0
U-234	420.0	1,100.0
Th-230	28,000.0	45,000.0
Ra-226	220.0	2,500.0
Pb-210	520.0	1,500.0
Po-210	400.0	520.0
Th-232 Decay Chain		
Th-232	24.0	34.0
Ra-228	<2.0	3.0
Th-228	24.0	15.0
Ra-224	<2.0	5.0
U-235 Decay Chain		
U-235	24.0	50.0
Pa-231	290.0[b]	350.0[b]
Ac-227	240.0	230.0
Th-227	290.0	350.0

[a]Average results are from a composite sample including all depth regions of 10 percent of the boreholes, with a minimum of 4 boreholes composited. Maximum results are from a sample selected from the borehole depth region that had the highest gamma levels of any depth region of any borehole in that unit.

[b]Based on the Th-227 value.

Table 14

Summary of Source Term Analysis

Location	Average Concentration	Maximum Concentration
SLDS Plant		
1	Disequilibrium conditions; Th-230 concentration greater than parent.	Disequilibrium conditions; uranium concentrations greater than other radionuclides.
2	Disequilibrium conditions; uranium concentrations greater than daughters.	Disequilibrium conditions; uranium concentrations greater than other radionuclides.
5	Equilibrium conditions; uranium concentrations slightly greater than daughters.	Disequilibrium conditions; some uranium daughter concentrations greater than parent.
6	Disequilibrium conditions; uranium concentrations greater than daughters.	Disequilibrium conditions; uranium concentrations greater than other radionuclides.
7	Equilibrium conditions.	Disequilibrium conditions; some uranium daughter concentrations greater than parent.
7E	Disequilibrium conditions; thorium concentration greater than parent.	Disequilibrium conditions; some uranium daughter concentrations greater than parent.
10	Disequilibrium conditions; Th-230 concentration greater than parent.	Disequilibrium conditions; U-238, U-234, and Th-230 occur in greater concentrations than other radionuclides.

Table 14

(continued)

Location	Average Concentration	Maximum Concentration
SLAPS Unit		
1	Disequilibrium conditions; Th-230 concentration greater than parent.	No sample.
2	Disequilibrium conditions; Th-230 concentration greater than parent.	Disequilibrium conditions; uranium daughter concentrations greater than parent.
3	Disequilibrium conditions; Th-230 concentration greater than parent.	No sample.
4	Disequilibrium conditions; Th-230 concentration greater than parent.	Disequilibrium conditions; uranium daughter concentrations greater than parent.
5	Disequilibrium conditions; thorium concentrations greater than daughter.	No sample.
HISS/Futura		
	Disequilibrium conditions; thorium concentrations greater than parent.	Disequilibrium conditions; thorium concentrations greater than parent.

APPENDIX E

TARGET COMPOUND LIST ESTIMATED DETECTION LIMITS

Table E-1

Target Compound List Estimated Detection Limits

Analyte	CAS Number	Estimated Detection Limits[a,b] Water (µg/L)	Soil/Sediment (µg/kg)
Volatiles[c,d]			
Chloromethane	74-87-3	10	10
Bromomethane	74-83-9	10	10
Vinyl chloride	75-01-4	10	10
Chloroethane	75-00-3	10	10
Methylene chloride	75-09-2	5	5
Acetone	67-64-1	10	10
Carbon disulfide	75-15-0	5	5
1,1-dichloroethene	75-35-4	5	5
1,1-dichloroethane	75-35-3	5	5
Trans-1,2-dichloroethene	156-60-5	5	5
Chloroform	67-66-3	5	5
1,2-dichloroethane	107-06-2	5	5
2-butanone	78-93-3	10	10
1,1,1-trichloroethane	71-55-6	5	5
Carbon tetrachloride	56-23-5	5	5
Vinyl acetate	108-05-4	10	10
Bromodichloromethane	75-27-4	5	5
1,1,2,2-tetrachloroethane	79-34-5	5	5
1,2-dichloropropane	78-87-5	5	5
Trans-1,2-dichloropropene	0061-02-6	5	5
Trichloroethene	79-01-6	5	5
Dibromochloromethane	124-48-1	5	5
1,1,2-trichloroethane	79-00-5	5	5
Benzene	71-43-2	5	5
Cis-1,3-dichloropropene	10061-01-5	5	5
2-chloroethyl vinyl ether	110-75-8	10	10
Bromoform	75-25-2	5	5
2-hexanone	591-78-6	10	10
4-methyl-2-pentanone	108-10-1	10	5
Tetrachloroethene	127-18-4	5	5
Toluene	108-88-3	5	5
Chlorobenzene	108-90-7	5	5
Ethyl benzene	100-42-4	5	5
Styrene	100-42-5	5	5
Total xylenes	100-42-5	5	5

Table E-1

(continued)

Analyte	CAS Number	Estimated Detection Limits[a,b] Water (µg/L)	Soil/Sediment (µg/kg)
Semivolatiles[e,f]			
N-nitrosodimethylamine	62-75-9	10	330
Phenol	108-95-2	10	330
Aniline	62-53-3	10	330
Bis(2-chloroethyl) ether	111-44-4	10	330
2-chlorophenol	95-57-8	10	330
1,3-dichlorobenzene	541-73-1	10	330
1,4-dichlorobenzene	106-46-7	10	330
Benzyl alcohol	100-51-6	10	330
1,2-dichlorobenzene	95-50-1	10	330
2-methylphenol	95-48-7	10	330
Bis(2-chloroisopropyl) ether	39638-32-9	10	330
4-methylphenol	106-44-5	10	330
N-nitroso-dipropylamine	621-64-7	10	330
Hexachloroethane	67-72-1	10	330
Nitrobenzene	98-95-3	10	330
Isophorone	78-59-1	10	330
2-nitrophenol	88-75-5	10	330
2,4-dimethylphenol	105-67-9	10	330
Benzoic acid	65-85-0	50	1,600
Bis(2-chloroethoxy)methane	111-91-1	10	330
2,4-dichlorophenol	120-83-2	10	330
1,2,4-trichlorobenzene	120-82-1	10	330
Naphthalene	91-20-3	10	330
4-chloroaniline	106-47-8	10	330
Hexachlorobutadiene	87-68-3	10	330
4-chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
2-methylnaphthalene	91-57-6	10	330
Hexachlorocyclopentadiene	77-47-4	10	330
2,4,6-trichlorophenol	88-06-2	10	330
2,4,5-trichlorophenol	95-95-4	50	1,600
2-chloronaphthalene	91-58-7	10	330
2-nitroaniline	88-74-4	50	1,600
Dimethyl phthalate	131-11-3	10	330
Acenaphthylene	208-96-8	10	330
3-nitroaniline	99-09-2	50	1,600

Table E-1

(continued)

Analyte	CAS Number	Estimated Detection Limits[a,b] Water (µg/L)	Soil/Sediment (µg/kg)
Semivolatiles[e,f] (continued)			
Acenaphthene	83-32-9	10	330
2,4-dinitrophenol	51-28-5	50	1,600
4-nitrophenol	100-02-7	50	1,600
Dibenzofuran	132-64-9	10	330
2,4-dinitrotoluene	121-14-2	10	330
2,6-dinitrotoluene	606-20-2	10	330
Diethylphthalate	84-66-2	10	330
4-chlorophenyl phenyl ether	7005-2-3	10	330
Fluorene	86-73-7	10	330
4-nitroaniline	100-01-6	50	1,600
4,6-dinitro-2-methylphenol	534-52-1	50	1,600
N-nitrosodiphenylamine	86-30-6	10	330
4-bromophenyl phenyl ether	101-55-3	10	330
Hexachlorobenzene	118-74-1	10	330
Pentachlorophenol	87-86-5	50	1,600
Phenanthrene	85-01-8	10	330
Anthracene	120-12-7	10	330
Di-n-butyl phthalate	84-74-2	10	330
Fluroanthene	206-44-0	10	330
Benzidine	92-87-5	50	1,600
Pyrene	129-00-0	10	330
Butyl benzyl phthalate	85-68-7	10	330
3,3'-dichlorobenzidine	91-94-1	20	660
Benzo(a)anthracene	56-55-3	10	330
Bis(2-ethylhexyl) phthalate	117-81-7	10	330
Chrysene	218-01-0	10	330
Di-n-octyl phthalate	117-84-0	10	330
Benzo(b)fluoranthene	205-99-2	10	330
Benzo(k)fluoranthene	207-08-9	10	330
Benzo(a)pyrene	50-32-8	10	330

Table E-1

(continued)

Analyte	CAS Number	Estimated Detection Limits[a,b] Water (µg/L)	Soil/Sediment (µg/kg)
Pesticides/PCBs[g,h]			
Indeno(1,2,3-cd)pyrene	193-39-5	10	330
Dibenz(a,h)anthracene	53-70-3	10	330
Benzo(g,h,i)perylene	191-24-2	10	330
Alpha-BHC	319-84-6	0.05	2.0
Beta-BHC	319-85-7	0.05	2.0
Delta-BHC	319-86-8	0.05	2.0
Gamma-BHC (lindane)	58-89-9	0.05	2.0
Heptachlor	76-44-8	0.05	2.0
Aldrin	309-00-2	0.05	2.0
Heptachlor epoxide	1024-57-3	0.05	2.0
Endosulfan I	959-98-8	0.05	2.0
Dieldrin	60-57-1	0.10	4.0
4,4'-DDE	72-55-9	0.10	4.0
Endrin	72-20-8	0.10	4.0
Endosulfan II	33213-65-9	0.10	4.0
4,4'-DDD	72-54-8	0.10	4.0
Endrin aldehyde	7421-93-4	0.10	4.0
Endosulfan sulfate	1031-07-8	0.10	4.0
4,4'-DDT	50-29-3	0.10	4.0
Endrin ketone	53494-70-5	0.10	4.0
Methoxychlor	72-43-5	0.5	20.0
Chlordane	57-74-9	0.5	20.0
Toxaphene	8001-35-2	1.0	40.0
AROCLOR-1016	12674-11-2	0.5	20.0
AROCLOR-1221	11104-28-2	0.5	20.0
AROCLOR-1232	11141-16-5	0.5	20.0
AROCLOR-1242	53469-21-9	0.5	20.0
AROCLOR-1248	12672-29-6	0.5	20.0
AROCLOR-1254	11097-69-1	1.0	40.0
AROCLOR-1260	11096-82-5	1.0	40.0

[a]Detection limits listed for soil/sediment are based on wet weight. The detection limits calculated by the laboratory for soil/sediment, (on dry weight basis as required by the contract) will be higher.

[b]Specific detection limits are highly matrix dependent. The detection limits listed herein are provided for guidance and may not always be achievable.

[c]Medium water contract required detection limits (CRDL) for volatile Target Compound List (TCL) compounds are 100 times the individual low water CRCL.

[d]Medium soil/sediment CRDL for volatile TCL compounds are 100 times the individual low soil/sediment CRDL.

[e]Medium water CRDL for semivolatile TCL compounds are 100 times the individual low water CRDL.

[f]Medium soil/sediment CRDL for semivolatile TCL compounds are 60 times the individual low soil/sediment CRDL.

[g]Medium water CRDL for pesticide TCL compounds are 100 times the individual low water CRDL.

[h]Medium soil/sediment CRDL for pesticide TCL compounds are 60 times the individual low soil/sediment CRDL.

APPENDIX F

REGULATORY REQUIREMENTS POTENTIALLY APPLICABLE TO REMEDIAL ACTION AT THE ST. LOUIS SITE

APPENDIX F
REGULATORY REQUIREMENTS POTENTIALLY APPLICABLE TO REMEDIAL ACTION AT ST. LOUIS SITE

Potential requirements for a proposed action can be grouped into two general categories: (1) applicable or relevant and appropriate requirements (ARARs) and (2) "to-be-considered" (TBC) requirements. The first category consists of promulgated standards (e.g., public laws codified at the state or federal level) that may be applicable or relevant and appropriate to all or part of the proposed action. The second category consists of standards or guidelines that have been published but not promulgated and that may have specific bearing on all or part of the action—e.g., DOE orders.

Any regulation, standard, requirement, criterion, or limitation under any federal or state environmental law may be either *applicable* or *relevant and appropriate* to a remedial action, but not both. Consistent with guidance from the EPA on ARARs, only applicable requirements are evaluated for offsite actions, whereas both applicable and relevant and appropriate requirements are evaluated for onsite actions. Onsite actions must comply with a requirement that is determined to be relevant and appropriate to the same extent as one that is determined to be applicable. However, a determination of relevance and appropriateness may be applied to only portions of a requirement, whereas a determination of applicability is applied to the requirement as a whole. Onsite actions must comply with substantive requirements of ARARs but not related administrative and procedural requirements. For example, remedial actions conducted onsite would not require a permit but would be conducted in a manner consistent with the permitted conditions. Only those state laws may become ARARs that are (1) promulgated, such that they are legally enforceable and generally applicable (i.e., consistently applied) and (2) more stringent than federal laws.

In addressing a requirement that may affect the proposed action, a determination is made regarding its relationship to (1) the location of the action, (2) the contaminants involved, and (3) the specific components of the action. A potential ARAR is applicable if its prerequisites or related conditions are specifically met by the conditions of the proposed action (e.g., location in a floodplain); if the conditions of a requirement are not specifically

applicable, then a determination must be made as to whether they are sufficiently similar to be considered both relevant *and* appropriate (e.g., in terms of contaminant similarities and the nature and setting of the proposed action).

Potential TBC requirements are typically considered only if no promulgated requirements exist that are either applicable or relevant and appropriate. Thus, TBC requirements may be considered secondary to ARARs; in fact, they are often based on promulgated standards and can necessitate the same degree of compliance as ARARs (e.g., DOE orders). Potential location-specific, contaminant-specific, and action-specific ARARs and TBC requirements for the proposed removal action are identified and evaluated in Tables F-1, F-2, and F-3, respectively.

The preliminary ARAR and TBC determinations for these requirements are also indicated on the tables. Because this appendix presents a comprehensive list of requirements with considerable overlap of regulated conditions, all determinations have been identified as "potentially" applicable, relevant and appropriate, or to be considered. These determinations will be finalized in consultation with the state of Missouri and EPA Region VII prior to implementation of the proposed action. During finalization, the requirements identified as potentially applicable will be reviewed to confirm direct applicability; only one requirement will be finalized from among those that regulate the same conditions. For those identified as potentially relevant and appropriate and TBC requirements, the specific portion(s) of the requirements that have bearing on the proposed action, and the manner in which compliance would be achieved, will be finalized. After the finalization process, certain of the requirements will remain potentially an ARAR or a TBC requirement as the action proceeds, pending identification of the existence of their prerequisites or regulated conditions (e.g., the presence of cultural resources of threatened or endangered species in the affected area).

TABLES FOR APPENDIX F

Table F-1 Potential Location-Specific Requirements

Potential ARAR	Location	Requirement	Preliminary Determination	Remarks
Antiquity Act; Historic Sites Act (16 USC 431-433; 16 USC 461-467; 40 CFR 6.301(a))	Land	Cultural resources, such as historic buildings and sites and natural landmarks, must be preserved on federal land to avoid adverse impacts.	Potentially applicable	No adverse impacts to such resources are expected to result from remedial action at the St. Louis site; however, if these resources were affected, the requirement would be applicable.
National Historic Preservation Act, as amended (16 USC 470 et seq.; 40 CFR 6.301(b); 36 CFR 800)	Land	The affect of any federally assisted undertaking must be taken into account for any district, site, building, structure, or object included in or eligible for the *National Register of Historic Places*.	Potentially applicable	No adverse impacts to such properties are expected to result from remedial action at the St. Louis site; however, if these resources were affected, the requirement would be applicable.
Archeological and Historic Preservation Act (16 USC 469; 40 CFR 6.301(c); PL 93-291; 88 Stat. 174)	Land	Prehistorical, historical, and archeological data that might be destroyed as a result of a federal, federally assisted, or federally licensed activity or program must be preserved.	Potentially applicable	No destruction of such data is expected to result from remedial action activities. The St. Louis site is located in an area that has been considerably disturbed by past human activities; therefore, this area is not expected to contain any such data. However, if these data were affected, the requirement would be applicable.
Archeological Resources Protection Act (16 USC 470(a))	Land	A permit must be obtained if an action on public or Indian lands could impact archeological resources.	Potentially applicable	No impacts to archeological resources are expected to result from remedial action activities. The St. Louis site is located in an area that has been considerably disturbed by past human activities; therefore, this area is not expected to contain any such resources. However, if these resources were affected, the requirement would be applicable.
Protection and Enhancement of the Cultural Environment (Executive Order 11593; 40 CFR 6.301)	Land	Historic, architectural, archeological, and cultural resources must be preserved, restored, and maintained, and must be evaluated for inclusion in the *National Register*.	Potentially applicable	No impacts to such resources are expected to result from remedial action activities. The St. Louis site is located in an area that has been considerably disturbed by past human activities; therefore, this area is not expected to contain any such resources. However, if these resources were affected, the requirement would be applicable.
Endangered Species Act, as amended (16 USC 1531-1543; 50 CFR 17.402; 40 CFR 6.302(h))	Any	Federal agencies must ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify any critical habitat.	Potentially applicable	No critical habitat exists in the affected area, and no adverse impacts to threatened or endangered species are expected to result from remedial action activities; however, if such species were affected, the requirement would be applicable.

Table F-1 (Cont'd)

Potential ARAR	Location	Requirement	Preliminary Determination	Remerks
Missouri Wildlife Code (1989) (RSMo. 252.240; 3 CSR 10-4.111), Endangered Species	Any	Endangered species, i.e., those designated by the Missouri Department of Conservation and the U.S. Department of the Interior as threetened or endangered (see 1978 Code, RSMo. 252.240) may not be pursued, taken, possessed, or killed.	Potentially appliceble	No critical habitat exists in the affected area, and no adverse impacts to threatened or endangered species are expected to result from remediel action activities. However, if such species were affected, the raquirement would be applicable.
Missouri Wildlife Code (1989) (RSMo. 252.240; 3 CSR 10-4.110) General Prohibition; Applications	Any	Wildlife, including their homes and eggs, may not be taken or molested.	Potentially relevant end appropriate	No wildlife would be actively taken or molested as part of the remedial action. However, wildlife could be disturbed during implementetion. Mitigative measures would be taken to minimize potential adverse impacts.
Missouri Wildlife Code (1989) (RSMo. 252.240; 3 CSR 10-4.115), Special Menagement Areas	Any	Wildlife may not be taken, pursued, or molested on any state or federal wildlife refuge or any wildlife management area, except under permitted conditions.	Potentially relevant and appropriate	Not applicable beceuse the St. Louis site is not a Wildlife refuge or management area. No wildlife would be actively taken, pursued, or molested in any wildlife areas as part of remedial action activitias. However, wildlife could be disturbed during implementation. Mitigative measures would be taken to minimize potential adverse impacts.
Missouri Wildlife Code (1978) (RSMo. 252.040), Taking of Wildlife -- Rules and Regulations	Any	Wildlife may not be taken or pursued, except under permitted conditions.	Potentially relevant and appropriate	No wildlife would be actively taken or pursued as part of remedial action activities. However, wildlife could be disturbed during implementation. Mitigative measures would be taken to minimize potential adverse impacts.
Missouri Wildlife Code (1978) (RSMo. 252.240), Endangered species importation, transportation or sale, when prohibited -- how designated -- penalty	Any	The Missouri Department of Conservation must file with the state a list of animal species designated as endangered (for subsequent consideration of related requirements).	Potentially applicable	No critical habitat exists in the effected area, and no edverse impacts to threatened or endangered species are expected to result from remedial action activities. However, if such species were affected, the requirement would be applicable.
Missouri Wildlife Code (1978) (RSMo. 252.210), Contamination of streams	Stream	It is unlawful to put eny deleterious substances into waters of the state in quantities sufficient to injure fish, except under precautionary measures approved by the commission.	Potentially applicable	It is not anticipated that quantities of delaterious substances sufficient to injure fish would be dischargad to any waters of the state.
Missouri Hazardous Waste Management Regulations (1987) 10CSR 25	Land	Landfill location standerds.	To be considered	Siting standards for hezerdous waste disposal facilities in Missouri may need to be considered when evaluating remedial action alternativ for the St. Louis site.

Table F-1 (Cont'd)

Potential ARAR	Location	Requirement	Preliminary Determination	Remarks
Fish and Wildlife Coordination Act (14 USC 441-444; 40 CFR 4.302(a))	Any	Adequate protection of fish and wildlife resources is required when any federal department or agency proposes or authorizes any modification (e.g., diversion or channeling) of any stream or other water body or any modification of areas affecting any stream or other water body.	Potentially applicable	No modification of streams or stream areas is planned as part of remedial action activities. If such modification occurred, the pertinent requirements of this act would be followed during implementation of any ection.
Floodplain Management (Executive Order 11988; 40 CFR 6.302(b))	Floodplain	Federal agencies must avoid, to the maximum extent possible, any adverse impacts associated with diract and indirect development of a floodplain.	Potentially applicable	Parts of the St. Louis site (i.e., HISS) is in a floodplain; the provisions of this regulation is applicable.
Governor'a Executive Order 82-19	Floodplain	Potantial affacts of actions taken in a floodplein must be evaluated to avoid adverse impacts.	Potentially applicable	Parts of the St. Louis site (i.e., HISS) is in a floodplain; the provisions of this reguletion is applicebie.
Protection of Wetlands (Executive Order 11990; 40 CFR 6.302(a))	Wetland	Federal agencies must avoid, to the extent possible, any adverse impacts associated with the dastruction or loss of wetlends and the support of new construction in wetlands if a practicable alternative exists.	Not en ARAR	No wetland exists in the affected area.

Table F-2 Potential Contaminant-Specific Requirements

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Safe Drinking Water Act (42 USC 300 G); Maximum Contaminant Levels (40 CFR 141, Subpart B); Secondary Maximum Contaminant Levels (40 CFR 193.3); National Primary and Secondary Drinking Water Regulations (54 FR 97, May 22, 1989, Proposed Rules); Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper (53 FR 160, August 18, 1988, Proposed Rules)	See table	Water	Maximum contaminant levels (MCLs) and secondary maximum contaminant levels (SMCLs) for drinking water supplies are as follows:	Potentially relevant and appropriate	Because the St. Louis site is not a public water system, these regulations are not applicable. Groundwaters at the St. Louis site are not currently utilized as drinking water sources; however, such groundwaters could be classified by the EPA as potentially potable. Surface waters near the SLDS, i.e., Missouri and Mississippi rivers, may be potential drinking water sources, and these standards may be relevant and appropriate.

Contaminant	Unit	MCL	SMCL
Metals:			
Antimony	µg/L	-	-
Arsenic	µg/L	50	-
Beryllium	µg/L	-	-
Cadmium	µg/L	10	-
Cobalt	µg/L	-	-
Copper	µg/L	-	1,000
Lead	µg/L	50	-
Molybdenum	µg/L	-	-
Nickel	µg/L	-	-
Selenium	µg/L	10	-
Thallium	µg/L	-	-
Anions:			
Nitrates (as N)	mg/L	10	-
Radionuclides:			
Gross alpha[a]	pCi/L	15	-
Radium-226 and radium-228	pCi/L	5	-

[a]Including radium-226 but excluding radon and uranium.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Madium	Requirement	Determination	Remarks
National Primary and Secondary Drinking Water Regulations (54 FR 97, May 22, 1989, Proposed Rules); Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper (53 FR 160, August 18, 1988, Proposed Rules)	See table	Water	Proposed maximum contaminant levels (PMCLs) and proposed secondary maximum contaminant levels (PSMCLs) for drinking water supplies are as follows: Contaminant / Unit / PMCL / PSMCL Metals: Antimony / µg/L / - / - Arsenic / µg/L / - / - Beryllium / µg/L / - / - Cadmium / ug/L / 5 / - Cobalt / µg/L / - / - Copper / µg/L / 1,300 / - Lead / µg/L / 5 / - Molybdenum / µg/L / - / - Nickal / µg/L / - / - Selenium / µg/L / 50 / - Thallium / µg/L / - / - Anions: Nitrate as N / mg/L / 10 / -	Potentially relevant and appropriate	Because the St. Louis site is not a public water system, these regulations are not applicable. Groundwater at the St. Louis site are not currently utilized as drinking water sources; however, such groundwaters could be classified by the EPA as potentially potable.
Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes (40 CFR 191.16)	Radionuclides	Any	Disposal systems for spent nuclear fuel or high-level or transuranic wastes shall not cause radionuclide concentrations averaged over any year in water withdrawn from any portion of a special source of ground water to exceed: (1) 5 pCi/L of Radium-226 and Radium 228; (2) 15 pCi/L of alpha-emitting radionuclides (including radium-226 and radium-228 but excluding radon); or (3) The combined concentration of radionuclides that emit either beta or gamma radiation that would produce an annual dose equivalent to the total body or any internal organ greater than 4 millirems per year if an individual consumed 2 liters per day.	Potentially relevant and appropriate	Because the St. Louis site is not a NRC regulated facility or a DOE disposal facility and the ground water at the site is not currently utilized as drinking water source (such groundwater could be classified by the EPA-as potentially potable), therefore, these standards are not applicable, however, the contaminant is similar therefore, these standards may be relevant and appropriate.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Missouri Safe Drinking Water Act and Missouri Public Drinking Water Regulations	See table	Water	Maximum contaminant levels (MCLs) and secondary maximum contaminant levels (SMCLs) for drinking water supplies are as follows:	Potentially relevant and appropriate	Because the St. Louis site is not a public water system, these regulations are not applicable. Groundwater at the St. Louis site are not currently utilized as drinking water sources; however, such groundwaters could be classified by the EPA as potentially potable.
Federal Water Pollution Control Act, Clean Water Act (33 USC 1251-1376; Water Quality Standards (40 CFR 131), National Pollutant Discharge Elimination System (40 CFR 122-125)	Any	Water	States are responsible for reviewing, establishing, and revising water quality standards in accordance with EPA guidance and approval. Permitting authority for surface water discharges is delegated to the states according to the National Pollutant Discharge Elimination System (NPDES) process.	Potentially applicable	State water quality standards would be applicable to any surface-water discharges.
Missouri Water Quality Standards, Antidegradation (10 CSR 7.031(2))	Those listed in specific criteria of state water quality standards	Water	When water quality exceeds levels necessary to protect benaficial uses, that quality shall be fully maintained and protected. Lowered water quality is allowable only under certain conditions and full satisfaction of intergovernmental and public participation provisions.	Potentially applicable	Any surface-water discharges are not anticipated to lower the water quality of the Missouri and Mississippi rivers.

Contaminant	Unit	MCL	SMCL
Metals:			
Antimony	ug/L	-	-
Arsenic	µg/L	50	-
Beryllium	µg/L	-	-
Cadmium	µg/L	10	-
Cobalt	µg/L	-	-
Copper	µg/L	-	1,000
Lead	µg/L	50	-
Molybdenum	µg/L	-	-
Nickel	µg/L	-	-
Selenium	µg/L	10	-
Thallium	µg/L	-	-
Anions:			
Nitrate (as N)	mg/L	10	-
Radionuclides:			
Gross alpha[a]	pCi/L	15	-
Radium-226 and radium-228	pCi/L	5	-

[a]Including radium-226 but excluding radon and uranium.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Missouri Water Quality Standards, General Criteria (10 CSR 20-7.031(3))	General	Water	No contaminant, by itself or in combination with other substances, shall prevent the waters of the state from being (a) free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits or prevent full maintenance of beneficial uses; (b) free from oil, scum, and floating debris in sufficient amounts to be unsightly or prevent full maintenance of beneficial uses; (c) free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor, or prevent full maintenance of beneficial uses; and (d) free from substances or conditions in sufficient amounts to have a harmful effect on human, animal, or aquatic life.	Potentially applicable	Any surface-water discharges are not anticipated to cause such effects in the water to which they would be discharged.
Missouri Water Quality Standards, Specific Criteria (10 CSR 20-7.031(4))	See table	Water	Water contaminants should not exceed the following limits:	Potentially applicable	These requirements are based on the most restrictive contaminant concentrations allowable for the designated uses of tributaries to the Missouri and Mississippi river, therefore, these requirements may be applicable to the remedial action.
Missouri Water Quality Standards, Toxic Substances (10 CSR 20-7.031(4)(B))		Water	Other potentially toxic substances for which sufficient toxicity data are not available may not be released to waters of the state until safe levels are demonstrated through bioassay studies.	Potentially applicable	No such substances are anticipated from leachate or runoff from St. Louis site soils.
Missouri Water Quality Standards, Radioactive Materials (10 CSR 7.031(4)(F))	Radionuclides	Water	All streams and lakes shall conform with state and federal limits for radionuclides established for drinking water supply.	Potentially applicable	This requirement may be applicable to remedial action activities.

Contaminant	Unit	Concentration
Metals:	µg/L	
Antimony	µg/L	146
Arsenic	µg/L	20
Beryllium	µg/L	5
Cadmium	µg/L	10
Cobalt	µg/L	1,000
Copper	µg/L	20
Lead	µg/L	50
Nickel	µg/L	100
Selenium	µg/L	10
Thallium	µg/L	13
Anions:		
Nitrate as N	mg/L	10

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	See table	Water	Residual concentrations of radionuclides in water in uncontrolled areas are limited to the following. (For known mixtures of radionuclidas, the sum of the ratios of the observed concentration of each radionuclide to its corresponding limit must not exceed 1.0.)	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the remedial action will comply.

Isotope	f_1 Value[a]	Concentration[b] (μCi/mL)
$U_{natural}$	0.05	6×10^{-7}
	0.002	6×10^{-6}
Uranium-238	0.05	6×10^{-7}
	0.002	6×10^{-6}
Uranium-235	0.05	6×10^{-7}
	0.002	5×10^{-6}
Uranium-234	0.05	5×10^{-7}
	0.002	5×10^{-6}
Protectinium-231	0.001	1×10^{-8}
Thorium-232	0.0002	5×10^{-8}
Thorium-230	0.0002	3×10^{-7}
Actinium-227	0.001	1×10^{-8}
Radium-228	0.2	1×10^{-7}
Radium-226	0.2	1×10^{-7}
Lead-210	0.2	3×10^{-8}
Polonium-210	0.1	8×10^{-8}

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Radiation Protection of the Public and the Environment (DOE Order 5400.5) (Cont'd)			Isotope / f_1 Value[a] / Concentration[b] (μCi/mL): Radon-222 — 3×10^{-9}; Radon-220 — 3×10^{-9}. [a] f_1 is the fraction of a stable element entering the gastrointestinal tract that reaches body fluids. [b] Exposure conditions assume an ingestion rate of 730 L/yr of water (based on exposure during 365 d/yr).		
	Radium and Thorium	Soil	The generic guidelines for residual concentrations of radium-226, radium-228, thorium-230, and thorium-232 are (a) 5 pCi/g averaged over the first 15 cm of soil below the surface and (b) 15 pCi/g averaged over 15-cm-thick layers of soil more than 15 cm below the surface.	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the remedial action will comply.
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits	Radiation	Air	For persons outside a controlled area, the maximum permissible whole-body dose due to sources in or migrating from the controlled area is limited to 2 mrem in any 1 hour, 0.1 rem in any 7 consecutive days, and 0.5 rem in any year. (Note: a controlled area is an area that requires control of access, occupancy, and working conditions for radiation protection purposes; 0.5 rem = 500 mrem.)	Potentially relevant and appropriate	These requirement may be applicable to protection of the public during implementation of the remedial action.
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	Radiation	Air	The basic dose limit for nonoccupationally exposed individuals is 100 mrem/yr above background, committed effective dose equivalent. Further, all radiation exposures must be reduced to levels as low as is reasonably achievable.	To be considered	Although not promulgated standards, these requirements are derived from such standards and they consistute requirements for protection of the public with which the remedial action will comply.
National Emission Standards for Hazardous Air Pollutants (40 CFR 61), Subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy (DOE) Facilities	Radionuclides other than radon-220 and radon-222	Air	Emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public in any year an effective dose equivalent of 10 mrem/yr.	Potentially applicable	Because of the nature of contamination at the St. Louis site, these requirements may be relevant and appropriate for the protection of the public during implementation of the remedial action because the Weldon Spring site is a DOE facility.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192)	Radon	Air	Releases of radon from tailings disposal piles must not exceed an average rate of 20 pCi/m^2-s or increase the annual average concentration in air outside the disposal site by more than 0.5 pCi/L.	Potentially relevant and appropriate	The St. Louis site is not a mill tailings site, so these requirements are not applicable; however, they may be relevant and appropriate because of the similarity in nature of contamination.
	Radon decay products	Air	The annual average (or equivalent) radon decay product concentration, including background, in any habitable building must not exceed 0.02 working level (WL) or a maximum of 0.03 WL -- where a WL is any combination of short-lived radon decay products in 1 liter of air, without regard to the degree of equilibrium, that will result in the emission of 1.3×10^5 MeV of alpha energy. (For radon-222 in equilibrium with its decay products, 1 WL = 100 pCi/L.)	Potentially relevant and appropriate	The St. Louis site is not a mill tailings site, so these requirements are not applicable; however, they may be relevant and appropriate because of the similarity in nature of contamination.
	External gamma radiation	Air	The level of external gamma radiation in any occupied or habitable building must not exceed the background level by more than 20 μR/h.	Potentially relevant and appropriate	The St. Louis site is not a mill tailings site, so these requirements are not applicable; however, they may be relevant and appropriate because of the similarity in nature of contamination.
	Radium-226 and Radium-228	Soil	Average concentrations of residual radioactive materials in soil over an area of 100 m^2 may not exceed background by more than 5 pCi/g in the top 15 cm of soil or 15 pCi/g in each 15-cm layer below the top layer.	Potentially relevant and appropriate	The St. Louis site is not a mill tailings site, so these requirements are not applicable; however, they may be relevant and appropriate because of the similarity in nature of contamination.
	Radionuclides	Water	Uranium byproducts material shal not (1) exceed the background level of molybdenum and uranium as set in a RCRA permit and (2) may not exceed: 5 pCi/L of Radium-226 and Radium-228 15 pCi/L of gross alpha-particle activity (excluding radon and uranium).	Potentially relevant and appropriate	The St. Louis site is not a mill tailing site, therefore, these standards are not applicable, however, they may be relevant and appropriate because of the similarity in the nature of contamination.
Environmental Radiation Protection for Nuclear Power Operations (40 CFR 190)	Radionuclides	Any	The annual dose equivalent may not exceed 25 mrems to the whole body, 75 mrems the thyroid and 25 mrems to any other organ (excluding radon and its daughters).	Potentially relevant and appropriate	The St. Louis site is not a commercial nuclear power operation with planned discharges which are part of a nuclear fuel cycle therefore, these standards are not applicable however, they may be relevant and appropriate because of the similarity in the nature of the contamination.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes (40 CFR 191.03)	Radionuclides	Any	Discharges from spent nuclear fuel or high-level or transuranic wastes at NRC licensed facilities shall not exceed 25 mrems to the whole body, 75 mrems to the thyroid, and 25 mrems to any other critical organs. Discharges from spent nuclear fuel or high-level or transuranic wastes at a DOE disposal facility shall not exceed 25 mrems to the whole body and 75 mrems to any critical organ.	Potentially relevant and appropriate.	Because the St. Louis site is not a NRC regulated facility or a DOE disposal facility and the ground water at the site is not currently utilized as drinking water source, (such groundwater could classified by the EPA-as potentially potable), however, therefore these standards are not applicable, however, the contaminant is similar therefore, these standards may be relevant and appropriate.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits	See table	Air	The concentrations of radionuclides in air outside a controlled area (above natural background), averaged over any calendar quarter, should not exceed the following limits:	Potentially applicable	These requirements may be applicable to protection of the public during implementation of any action.

Isotope	Solubility Class	Concentration (μCi/mL)
$U_{natural}$	Soluble	3×10^{-12}
	Insoluble	2×10^{-12}
Uranium-238	Soluble	3×10^{-12}
	Insoluble	5×10^{-12}
Uranium-235	Soluble	2×10^{-11}
	Insoluble	4×10^{-12}
Uranium-234	Soluble	2×10^{-11}
	Insoluble	4×10^{-12}
Protactinium-231	Soluble	4×10^{-14}
	Insoluble	4×10^{-12}
Thorium-232	Soluble	7×10^{-14}
	Insoluble	4×10^{-13}
Thorium-230	Soluble	8×10^{-14}
	Insoluble	3×10^{-13}
Actinium-227	Soluble	8×10^{-14}
	Insoluble	9×10^{-13}
Radium-228	Soluble	2×10^{-12}
	Insoluble	1×10^{-12}
Lead-210	Soluble	4×10^{-12}
	Insoluble	8×10^{-12}
Polonium-210	Soluble	2×10^{-11}
	Insoluble	7×10^{-12}

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040). Maximum Permissible Exposure Limits (Cont'd)			Isotope / Solubility Class / Concentration (μCi/mL): Radium-226 — Soluble 1×10^{-12}, Insoluble 6×10^{-9}; Radon-222 — 1×10^{-9}; Radon-220 — 1×10^{-8}		
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	See table	Air	Residual concentrations of radionuclides in air in uncontrolled areas are limited to the following. (For known mixtures of radionuclides, the sum of the ratios of the observed concentration of each radionuclide to its corresponding limit must not exceed 1.0.)	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the remedial action will comply.

Derived Concentration Guide[a] (μCi/ml)

Isotope	D	W	Y
Uranium-238	5×10^{-12}	2×10^{-12}	1×10^{-13}
Uranium-235	5×10^{-12}	2×10^{-12}	1×10^{-13}
Uranium-234	4×10^{-12}	2×10^{-12}	9×10^{-14}
Protactinium-231	-[b]	9 x 10-5	1 x 10-14
Thorium-232	-[b]	7×10^{-15}	1×10^{-14}
Thorium-230	-	4×10^{-14}	5×10^{-14}
Actinium-227	2 x 10-15	7 x 10-15	1 x 10-14
Radium-228	-	3×10^{-12}	-
Radium-226	-	1×10^{-12}	-

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Radiation Protection of the Public and the Environment (DOE Order 5400.5) (Cont'd)			Derived Concentration Guide[a] (μCi/ml) Isotope D W Y Lead-210 9 x 10−13 - - Polonium-210 1 x 10−12 1 x 10−12 - [a]D, W, and Y represent lung retention classes; removal half-times assigned to the compounds with classes D, W, and Y are 0.5, 50, and 500 days, respectively. Exposure conditions assume an inhalation rate of 8,400 m^3 of air per year (based on an exposure over 24 hours per day, 365 days per year). [b]A hyphen means no limit has been established.		
	Radon-222	Air	The above-background concentration of radon-222 in air above an interim storage facility must not exceed 100 Pci/L at any point, an annual average of 30 pCi/L over the facility, or an annual average of 3 pCi/L at or above any location outside the site. (See also the discussion for DOE Order 5820.2A in Table B.3)	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the remedial action will comply.
	Radon-220 and radon-222	Air	The immersion derived concentration guide for both radon-220 and radon-222 in air in an uncontrolled area is 3 pCi/L.	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the remedial action will comply.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910; 1910.96), Subpart G, Ionizing Radiation	Radiation	Any	The dose per calendar quarter resulting from exposure to radiation in a restricted area from sources in that area is limited to the following: Part of Body — Dose (rem) Whole body: head and trunk; active blood-forming organs; lens of eye; or gonads — 1 1/4 Hands and forearms; feet and ankles — 18 3/4 Skin of whole body — 7 1/2 The occupational exposure of an individual younger than 18 is restricted to 10% of these limits; the whole-body dose to a worker may not exceed 3 rem in a calendar quarter, and when added to the cumulative occupational dose may not exceed 5(N-18) rem, where N is the age of the exposed individual.	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. However, they constitute requirements for worker protection with thich the response actions will comply.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits	Radiation	Any	Limits for occupational doses from ionizing radiation in a controlled area are as follows: Quarter Part of Body — Maximum Dose In Any Calendar Year (rem) — Maximum Dose In Any Calendar (rem) Whole body: head and trunk; major portion of bone marrow; gonads; or lens of eye — 5 — 3 Hands and forearms; feet and ankles — 75 — 25 Skin of large body area — 30 — 10 Also, the whole-body dose added to the cumulative occupational dose must not exceed 5(N-18) rem, where N is the age of the exposed individual.	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. However, they constitute requirements for worker protection with which the response actions will comply.
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.050), Personnel Monitoring and Radiation Surveys	Radiation	Any	Personnel monitoring and radiation surveys are required for each worker for whom there is any reasonable possibility of receiving a weekly dose from all radiation exceeding 50 mrem, taking into consideration the use of protective gloves and radiation-limiting devices. An exemption from routine monitoring may be granted under certain conditions.	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. However, they constitute requirements for worker protection with which the response actions will comply.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Radiation Protection for Occupational Workers (DOE Order 5480.11)	Radiation	Any	The effective dose equivalent received by any member of the public entering a controlled area is limited to 100 mrem/yr. Limiting values for the assessed dose from exposure of workers to radiation are as follows. (These values represent maximum limits; it is DOE policy to maintain radiation exposures as far below these limits as is reasonably achievable.)	To be considered	Although not promulgated standards, these constitute requirements for protection from radionuclide emissions in a controlled area with which the remedial action will comply.

Radiation Effect	Annual Dose Equivalent (rem)
Stochastic effects	5[a]
Nonstochastic effects	
Lens of eye	15
Organ, extremity, or tissue including skin of whole body	50
Unborn child Entire gestation period	0.5

[a]Annual effective dose equivalent.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910; 1910.96), Subpart G, Ionizing Radiation	Uranium, thorium, radium, and radon	Water	Within a restricted area, airborne radioactive material (averaged over a 40-hour work week of seven consecutive days) should not exceed the following limits. (For hours of exposure less than or greater than 40, the limits are proportionately increased or decreased, respectively.)	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. However, they constitute requirements for worker protection with which the proposed action should comply.

Isotope	Solubility Class	Concentration (μCi/mL)
$U_{natural}$	Soluble	5×10^{-12}
	Insoluble	5×10^{-12}
Uranium-238	Soluble	3×10^{-12}
	Insoluble	5×10^{-12}
Uranium-235	Soluble	2×10^{-11}
	Insoluble	4×10^{-12}
Uranium-234	Soluble	2×10^{-11}
	Insoluble	4×10^{-12}
Protactinium-231	Soluble	4 x 10-14
	Insoluble	4 x 10-12
Thorium-232	Soluble	1×10^{-12}
	Insoluble	1×10^{-12}
Thorium-230	Soluble	8×10^{-14}
	Insoluble	3×10^{-13}
Actinium-227	Soluble	8 x 10-14
	Insoluble	9 x 10-13

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks

Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910; 1910.96), Subpart G, Ionizing Radiation (Cont'd)

Isotope	Solubility Class	Concentration (μCi/mL)
Radium-228	Soluble	2×10^{-12}
	Insoluble	1×10^{-12}
Radium-226	Soluble	3×10^{-12}
	Insoluble	2×10^{-12}
Lead-210	Soluble	1 × 10-10
	Insoluble	2 × 10-10
Polonium-210	Soluble	5 × 10-10
	Insoluble	2 × 10-10
Radon-222[a]		3×10^{-9}
Radon-220		1×10^{-8}

[a]Limit is appropriate for radon-222 combined with its short-lived decay products and may be replaced by 1/3 WL; the limit in restricted areas may be based on an annual average.

For mixtures of radionuclides, the sum of the ratios of the quantity present to the specific limit must not exceed 1. For uranium, chemical toxicity may be the limiting factor for soluble mixtures of uranium-238, uranium-235, and uranium-234 in air; if the percent by weight of uranium-235 is less than 5, the concentration limit for uranium is 0.007 mg/m^3 inhaled air.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits	See table	Air	Concentrations of radionuclides in air, averaged over any calendar quarter, should not exceed the following limits. (Limits apply to exposure in a controlled area and are based on a work week of 40 hours; for longer work weeks, the values must be adjusted downward.)	Not an ARAR	These requirements are part of an employee protection law (rather than environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. However, they constitute requirements for worker protection with which the response actions will comply.

Isotope	Solubility Class	Concentration (μCi/mL)
$U_{natural}$	Soluble	7×10^{-11}
	Insoluble	6×10^{-11}
Uranium-238	Soluble	7×10^{-11}
	Insoluble	1×10^{-10}
Uranium-235	Soluble	5×10^{-10}
	Insoluble	1×10^{-10}
Uranium-234	Soluble	6×10^{-10}
	Insoluble	1×10^{-10}
Protactinium-231	Soluble	1 x 10-12
	Insoluble	1 x 10-10
Thorium-232	Soluble	2×10^{-12}
	Insoluble	1×10^{-11}
Thorium-230	Soluble	2×10^{-12}
	Insoluble	1×10^{-11}
Actinium-227	Soluble	2 x 10-12
	Insoluble	3 x 10-11

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
			Isotope / Solubility Class / Concentration (μCi/mL): Radium-228 Soluble 7×10^{-11}; Insoluble 4×10^{-11}; Radium-226 Soluble 3×10^{-11}; Insoluble 2×10^{-7}; Lead-210 Soluble 1 × 10-10; Insoluble 2 × 10-10; Polonium-210 Soluble 5 × 10-10; Insoluble 2 × 10-10; Radon-222 3×10^{-8}; Radon-220 3×10^{-7}		
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits	See table	Water	Concentrations of radionuclides in water, averaged over any calendar quarter, should not exceed the following limits. (Limits apply to exposure in a controlled area and are based on a work week of 40 hours; for longer work weeks, the values must be adjusted downward.) Isotope / Solubility Class / Concentration (μCi/mL): $U_{natural}$ Soluble 2×10^{-5}; Insoluble 2×10^{-5}; Uranium-238 Soluble 4×10^{-5}; Insoluble 4×10^{-5}	Not an ARAR	These requirements are part of an employee protection law (rather than environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. However, they constitute requirements for worker protection with which the response actions will comply.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement			Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits (Cont'd)			Isotope	Solubility Class	Concentration (μCi/mL)		
			Uranium-235	Soluble	3×10^{-5}		
				Insoluble	3×10^{-5}		
			Uranium-234	Soluble	3×10^{-5}		
				Insoluble	3×10^{-5}		
			Protactinium-231	Soluble	9×10^{-7}		
				Insoluble	2×10^{-5}		
			Thorium-232	Soluble	2×10^{-6}		
				Insoluble	4×10^{-5}		
			Thorium-230	Soluble	2×10^{-6}		
				Insoluble	3×10^{-5}		
			Actinium-227	Soluble	2×10^{-6}		
				Insoluble	3×10^{-4}		
			Radium-228	Soluble	3×10^{-8}		
				Insoluble	3×10^{-5}		
			Radium-226	Soluble	1×10^{-6}		
				Insoluble	3×10^{-5}		
			Lead-210	Soluble	-		
				Insoluble	-		
			Polonium-210	Soluble	-		
				Insoluble	-		

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Radiation Protection for Occupational Workers (DOE Order 5480.11)	See table	Air	Occupational exposure limits for specific radionuclides in air are as follows. (Values for radon isotopes assume 100% equilibrium with the short-lived decay products; these values may be replaced by 1 WL for radon-220 and 1/3 WL for radon-222.)	To be considered	Although not promulgated standards, these constitute requirements for worker protection with which the remedial action will comply.

	Derived Concentration Guide[a] (μCi/ml)		
Isotope	D	W	Y
Uranium-238	6×10^{-10}	3×10^{-10}	2×10^{-11}
Uranium-235	8×10^{-10}	3×10^{-10}	2×10^{-11}
Uranium-234	5×10^{-10}	3×10^{-10}	2×10^{-11}

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks

Radiation Protection for Occupational Workers (DOE Order 5480.11) (Cont'd)

(Cont'd)

Isotope	Derived Concentration Guide[a] (μCi/Ml) D	W	Y
Protachinium-231	-[b]	7 × 10-13	2 × 10-12
Thorium-232	-[b]	5 × 10^{-13}	1 × 10^{-12}
Thorium-230	-	3 × 10^{-12}	7 × 10^{-12}
Actinium-227	2 × 10-13	7 × 10-13	2 × 10-12
Radium-228	-	5 × 10^{-10}	-
Radium-226	-	3 × 10^{-10}	-
Lead-210	1 × 10-10	-	-
Polonium-210	3 × 10-10	3 × 10-10	-
Radon-222	3 × 10^{-8}	-	-
Radon-220	8 × 10^{-9}	-	-

[a] D, W, and Y represent lung retention classes; removal half-times assigned to the compounds with classes D, W, and Y are 0.5, 50, and 500 days, respectively. Exposure conditions assume an inhalation rate of 2,400 m^3 of air per year (based on an exposure over 40 hours per week, 50 weeks per year).

[b] A hyphen means no limit has been established.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Occupational Safety and Health Administration Standards (29 CFR 1910; 1910.1000), Subpart Z, Toxic and Hazardous Substances	Specific organic and inorganic substances	Air	Permissible occupational exposure limits for various airborne substances have recently been revised to the following final rule limits; they may be achieved by any reasonable combination of engineering controls, work practices, and personal protective equipment.	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. However, they constitute requirements for worker protection with which the response action will comply.

Substance	Limit[a] (mg/m^3)	Condition
Polynuclear aromatic hydrocarbons	0.2	Limit applies to the benzene-soluble fraction of volatiles from coal tar pitch.
Arsenic	0.01	For inorganic compounds, as arsenic.
Lead	0.05	For metallic lead and inorganic compound, as lead.
Nickel	0.1	For soluble compounds, as nickel; limit for metallic nickel and insoluble compounds, as nickel, is $1 mg/m^3$
Selenium	0.2	As selenium.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Occupational Safety and Health Administration Standards (29 CFR 1910; 1010.1000), Subpart Z, Toxic and Hazardous Substances (Cont'd)			(Cont'd) Substance / Limit[a] (mg/m^3) / Condition Uranium — 0.05 — For soluble compounds, as uranium; limit for insoluble compounds; as uranium, is 0.2 mg/m^3 with a short-term (15-minute) exposure limit of 0.6 mg/m^3. Particulates: Total dust — 15 — For particulates not otherwise regulated (i.e., nuisance dust). Respirable fraction — 5 [a]Permissible exposure limit expressed as the 8-hour time-weighted average.		
Clean Air Act, as amended (42 USC 7401-7642); National Primary and Secondary Ambient Air Quality Standards (40 CFR 50)	Particulate matter	Air	For a major stationary source (see 40 CFR 52.2(b)(1)(i)(a)) that emits >250 tons/year of any regulated pollutant or >100 tons/year of a regulated pollutant for which the area is designated as non-attainment, particulate matter less than 10 μm in diameter (PM-10) should not exceed a 24-hour average concentration of 150 $\mu g/m^3$ or an annual arithmetic mean of 50 $\mu g/m^3$.	Not an ARAR	These requirements do not apply directly to source specific emissions; rather, they are national limitations or ambient concentrations. However, they will be addressed in controlling emissions of particulates that could result from implementation of the proposed action.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Missouri Air Conservation Law; Public Health and Welfare (RSMo. Title 12, 203.055), Commission may adopt rules for compliance with federal law -- suspension, reinstatement	Any regulated under federal Clean Air Act	Air	Standards and guidelines promulgated to ensure that Missouri is in compliance with the Clean Air Act are not to be any stricter than those required under that act (see related discussion of 40 CFR 50).	Not an ARAR	These requirements do not apply directly to source-specific emissions; rather, they are national limitations or ambient concentrations. However, they will be addressed in controlling emissions of particulates that could result from implementation of the remedial action.
Missouri Air Quality Standards; Air Quality Standards, Definitions, Sampling and Reference Methods, and Air Pollution Control Regulations for the State of Missouri (10 CSR 10-6.010), Ambient Air Quality	Particulate matter (PM-10)	Air	Concentrations of PM-10 are limited to an annual arithmetic mean of 50 $\mu g/m^3$ and a 24-hour average of 150 $\mu g/m^3$. (These Missouri regulations cover the St. Louis metropolitan area, which includes the geographic areas of St. Charles County.)	Not an ARAR	These requirements do not apply directly to source-specific emissions; rather, they are national limitations or ambient concentrations. However, they will be addressed in controlling emissions of particulates that could result from implementation of the remedial action.
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.050), Restriction of Emission of Particulate Matter from Industrial Processes	Particulate matter	Air	Particulate matter from any industrial source may not exceed a concentration of 0.30 grain/ft^3 of exhaust gas; certain activities are exempted (e.g., grinding, crushing, and classifying operations at a rock quarry).	Not an ARAR	These requirements are neither applicable nor relevant and appropriate because no industrial processes are involved in the proposed action. However, they will be addressed in controlling particulate emissions that could be generated during implementation.
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.090), Restriction of Emission of Visible Air Contaminants	Particulate matter	Air	Emissions of particulate matter (< 25 lb/h) from any single source, not including uncombined water, may not be darker than the shade of density designated as No. 2 on the Ringelmann Chart, or 40% opacity.	Not an ARAR	These requirements are neither applicable nor relevant and appropriate because the site does not constitute an emission source, per the regulatory definition. However, they will be addressed in controlling particulate emissions that could result during implementation.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.100), Preventing Particulate Matter from Becoming Airborne	Particulate matter	Air	No person may permit the handling, transport, or storage of any material in a way that allows unnecessary amounts of fugitive particulate matter to become airborne and that results in at least one complaint being filed. To prevent particulate matter from becoming airborne during construction, use, repair, or demolition of a road, driveway, or open area, the following measures may be required: paving or frequent cleaning of roads, applying dust-free surfaces or water, and planting and maintaining a vegetative ground cover. (Unpaved public roads in unincorporated areas that are in compliance with particulate matter standards are excluded.)	Potentially relevant and appropriate	These requirements may be relevant and appropriate to the control of particulate emissions that could result during implementation.
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.180), Emission of Visible Air Contaminants from Internal Combustion Engines	Particulate matter	Air	Visible air contaminants (other than uncombined water) may not be released from an internal combustion engine for more than 10 seconds at any one time.	Potentially applicable	These requirements may be applicable to particulates released from any internal combustion engines used during implementation of the remedial action.
National Emission Standards for Hazardous Air Pollutants (40 CFR 61), Subpart M, National Emission Standard for Asbestos	Asbestos	Air	Warning signs must be posted, and discharge of visible emissions must not occur during the collection, processing, packaging, transporting, or deposition of any asbestos-containing material.	Potentially applicable	These requirements may be applicable to protection of the public if any asbestos emissions result from a specific response activity (e.g., for a building renovation or decontamination activity).
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469 et seq.); Asbestos (40 CFR 763), Subpart G, Asbestos Abatement Projects	Asbestos	Air	Programs for worker training and protection (via clothing and equipment) must be implemented, and the permissible exposure limit for asbestos is 0.2 fiber/cm^3 of air as an 8-hour time-weighted average.	Not an ARAR	These requirements are part of an employee protection law rather than an environmental law) with which CERCLA response actions should comply; hence they are not subject to the ARAR process. However, they constitute requirements for worker protection with which the response actions will comply.
Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910; 1910.1001), Subpart G, Asbestos, Tremolite, Anthophyllite, and Actinolite	Asbestos	Air	Various asbestos-management activities are required for worker protection, including monitoring, timely response to releases, and the use of high-efficiency-particulate-air (HEPA)-filtered equipment for vacuuming. The permissible occupational exposure limit for asbestos as an 8-hour time-weighted average is 0.2 fiber/cm^3 of air.	Not an ARAR	These requirements are part of an employee protection law rather than an environmental law) with which CERCLA response actions should comply; hence they are not subject to the ARAR process. However, they constitute requirements for worker protection with which the response actions will comply.

Table F-2 (Cont'd)

Potential ARAR	Contaminant	Medium	Requirement	Determination	Remarks
Occupational Safety and Health Administration Construction Industry Standards (29 CFR 1926)	Asbestos	Air	Worker health and safety standards include a limit for occupational exposure to asbestos of 0.2 fiber/cm^3 of air as an 8-hour time-weighted average, with an action level of 0.1 fiber/cm^3 and a short-term (30-minute) limit of 1 fiber/cm^3 of air (fibers >5 μm).	Not an ARAR	These requirements are part of an employee protection law rather than an environmental law) with which CERCLA response actions should comply; hence they are not subject to the ARAR process. However, they constitute requirements for worker protection with which the response actions will comply.
Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910; 1910.95), Subpart G, Occupational Noise Exposure	Noise	Air	The permissible occupational exposure level for noise is 90 dBA (slow response) for an 8-hour day; with decreasing times of exposure, the levels increase to 115 dBA per 1/4-hour day.	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence they are not subject to the ARAR process. However, they constitute requirements for worker protection with which the response actions will comply.

Table F-3 Potential Action-Specific Requirements

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
Noise Control Act, as Amended; Noise Pollution and Abatement Act	Demolition	The public must be protected from noises (e.g., that could result from demolition activities) that jeopardize health or welfare.	Potentially applicable	Because equipment and vehicles would be involved in certain aspects of the proposed action, all pertinent requirements of the act would be followed.
Occupational Safety and Health Administration Standards for Hazardous Waste Operations and Emergency Response (29 CFR 1910)	Waste management	General worker protection requirements are established, as are requirements for worker training and the development of an emergency response plan and a safety and health program for employees. In addition, procedures are established for hazardous waste operations -- including decontamination and drum/container handling (e.g., for radioactive waste, asbestos, and PCBs).	Potentially applicable	Certain substantive components of these requirements may be applicable to worker protection during implementation of the remedial action. Emergency response plans and safety and health plans have been developed for response actions at the site.
Radioactive Waste Management (DOE Order 5820.2A)	Waste management	External exposure to radioactive waste (including releases) should not result in an effective dose equivalent of > 25 mrem/yr to any member of the public; releases to the atmosphere are to meet the requirements of 40 CFR 61 (see related discussion in Table B.2); and an environmental monitoring program must be implemented to address compliance with performance standards.	To be considered	Although not promulgated standards, these constitute requirements with which the remedial action will comply. An environmental monitoring program has been developed for implementation.
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	Interim waste storage and management	The control and stabilization features of a storage facility should be designed to ensure an effective life of 50 years, with a minimum life of at least 25 years, to the extent reasonably achievable; site access controls should be designed to ensure and effective life of at least 25 years, to the extent reasonable; and periodic monitoring, shielding, access restrictions, and safety measures must be implemented to control the migration of radioactive material, as appropriate.	To be considered	Although not promulgated standards, these constitute requirements with which the storage of wastes resulting from this action will comply.

Table F-3 (Cont'd)

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.080), Control of Radioactive Contamination	Waste management	All work must be carried out under conditions that minimize the potential spread of radioactive material that could result in the exposure of any person above any limit specified in 19 CSR 20-10.040 (see related discussion in Table B.2). Clothing and other personal contamination should be monitored and removed according to procedures established by a qualified expert; any material contaminated to the degree that a person could be exposed to radiation above any limit specified in 19 CSR 20-10.040 should be retained on-site until it can be decontaminated or disposed of according to procedures established by a qualified expert.	Potentially applicable	These requirements may be applicable to the management of radioactive wastes resulting from implementation of the remedial action.
Missouri Hazardous Substance Rules (10 CSR 24); Missouri Solid Waste Management Law (RSMo. 260.200 to 260.245) and Regulations (10 CSR 80); Missouri Hazardous Waste Management Law (RSMo. 260.350 to 260.552) and Regulations (10 CSR 25)	Waste treatment storage, and disposal	Various requirements are identified for waste treatment, storage, and disposal facilities.	Potentially applicable	The RCRA requirement for generation, transportation, and storage of hazardous wastes are applicable because RCRA hazardous wastes have been detected at the SLDS in concentrations above EPA criteria for hazardous characteristics in soil. Land disposal restrictions may be applicable if sufficient concentrations of particular hazardous wastes identified in 40 CFR 268 are stored on-site. Missouri is an authorized state under RCRA, and Missouri state regulations replace federal regulations. For those federal standards for which Missouri has not yet received authorization, federal regulations will apply; therefore, both state and federal regulations must be evaluated.

Table F-3 (Cont'd)

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	Decontamination	Structural debris that is released from DOE facilities for reuse without radiological restrictions should be decontaminated to the following levels.	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the proposed action will comply.

Radionuclides[b]	Allowable Total Residual Surface Contamination (dpm/100 cm^2)[a]		
	Average[c,d]	Maximum[e]	Removable[d,f]
Transuranics, iodine-125, iodine-129, radium-226, actinium-227, radium-228, thorium-228, thorium-230, protactinium-231	Reserved	Reserved	Reserved
Thorium-natural, strontium-90, iodine-126, iodine-131, iodine-133, radium-223, radium-224, uranium-232, thorium-232	1,000	1,000	200

Table F-3 (Cont'd)

Potential ARAR	Action	Requirement			Preliminary Determination	Remarks
(Cont'd)						

	Allowable Total Residual Surface Contamination (dpm/100 cm^2)[a]		
Radionuclides[b]	Average[c,d]	Maximum[e]	Removable[d,f]
Uranium-natural, uranium-235, uranium-238, and associated decay products, alpha emitters	5,000	15,000	1,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except strontium-90 and others noted above[g]	5,000	15,000	1,000

[a] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

Table F-3 (Cont'd)

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
(Cont'd)		[b]Where surface contamination by both alpha- and beta- gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently. [c]Measurements of average contamination should not be averaged over an area of more than 1 m^2. For objects of smaller surface area, the average should be derived for each such object. [d]The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm. [e]The maximum contamination level applies to an area of not more than 100 cm^2. [f]The amount of removable material per 100 cm^2 of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper (applying moderate pressure) and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination. [g]This category of radionuclides includes mixed fission products, including strontium-90, that have been separated from other fission products or mixtures where the strontium-90 has been enriched.		

Table F-3 (Cont'd)

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amanded (42 USC 6901, edt seq.); Solid Wastes (40 CFR 264), Subpart B, General Facility Standards	Waste Treatmant storage, or disposal	General requirements are established for facility location and inspection, waste compatibility determination, and worker training. Location requirements includs (1) fecilities must not be located within 61 m (200 ft) of a fault in which displacement has occurrad in Holocene time (i.e., since the end of the Pleistocene) and (2) facilities located in a 100-year floodplain must be constructed, operated, and maintained to prevent washout of any hezardous waste by a 100-year flood.	Potentially applicable	The RCRA requirement for generation, transportation, and storage of hezardous wastes are applicable becausa RCRA hazardous wastas have baen detected at the SLDS in concentrations above EPA criteria for hazardous characteristics in soil. Land disposal restrictions may be applicable if sufficient concentrations of particular hezardous wastes identified in 40 CFR 268 are storad onsite. Missouri is an authorized state under RCRA, and Missouri state regulations replace federal regulations. For thosa federal standards for which Missouri has not yet received authorization, federal regulations will apply; therefore, both state and federal regulations must be avaluated.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart C, Preparedness and Prevention; Subpart D, Contingency Plan and Emergency Procedures	Waste treatmant storage, or disposal	Facilities must be designed, constructed, maintained, and operated to minimize the possibility of fire, explosion, or any unplanned sudden or nonsudden release of hazardous waste (or constituents) to air, water, or surface water that could threaten human health or the environment. A contingency plan must be in place and emergency procedures must be implamented to minimiza relaasas of hazardous wastes from e facility.	Potentially applicable	The RCRA requirement for generation, transportation, and storage of hazardous wastes are applicable bacause RCRA hazardous wastas hava baen detected at the SLDS in concentrations above EPA criteria for hazardous characteristics in soil. Land disposal restrictions may be applicable if sufficiant concentrations of particular hezardous wastes identified in 40 CFR 268 are stored onsite. Missouri is an authorized state under RCRA, and Missouri has not yet received authorization, federal regulations will apply; therefore, both state and federal regulations must be evaluated.

Table F-3 (Cont'd)

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
Noise Control Act, as Amended; Noise Pollution and Abatement Act	Demolition	The public must be protected from noises (e.g., that could result from demolition activities) that jeoperdize health or welfare.	Potentially applicable	Because equipment and vehicles would be involved in certain espects of the proposed action, all pertinent requirements of the act would be followed.
Occupational Safety and Health Administration Standards for Hazardous Waste Operations and Emergency Response (29 CFR 1910)	Waste menegement	General worker protection requirements are established, as are requirements for worker training and the development of an emergency response plan and a safety and health program for employees. In eddition, procedures are established for hezardous waste operations -- including decontamination and drum/container handling (e.g., for radioactive waste, asbestos, and PCBs).	Not en ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. However, they constitute requirements for worker protection with which the response actions will comply.
Radioactive Waste Menegement (DOE Order 5820.2A)	Waste management	External exposure to radioactive waste (including releases) should not result in an effective dose equivalent of > 25 mrem/yr to any member of the public; releases to the atmosphere are to meet the requirements of 40 CFR 61 (see related discussion in Table B.2); and an environmental monitoring program must be implemented to address compliance with performance standards.	To be considered	Although not promulgated standards, these constitute requirements with which the remedial action will comply. An environmental monitoring program has been developed for implementation.
Rediation Protection of the Public and the Environment (DOE Order 5400.5)	Interim waste storage and menegement	The control and stabilization features of a storage facility should be designed to ensure an effective life of 50 years, with a minimum life of at least 25 years, to the extent reasonably achievable; site access controls should be designed to ensure end effective life of at least 25 years, to the extent reasonable; and periodic monitoring, shielding, access restrictions, and safety measures must be implemented to control the migration of radioective material, as appropriate.	To be considered	Although not promulgated standards, these constitute requirements with which the storage of wastes resulting from this action will comply.

Table F-3 (Cont'd)

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, at seq.); Solid Wastes (40 CFR 264), Subpart E, Manifest System, Recordkeeping, and Reporting; Subpart F, Releases from Solid Waste Management Units; Subpart G, Closure and post-Closure; Subpart H, Financial Requirements; Subpart K, Surface Impoundments; Subpart L, Waste Piles, Subpart M, Land Treatment; Subpart N, Landfills; Subpart O, Incinerators; Subpart P, Thermal Treatment; Subpart X, Miscellaneous Units	Waste treatment storage, or disposal	Various requirements (e.g., for facility design, operation, and closure, as appropriate) are established for treatment, storage, and disposal of hazardous wastes.	Potentially applicable	The RCRA requirements for generations, transportation and storage of hazardous wastes are applicable because RCRA hazardous wastes have been detected at the SLDS in concentration above EPA criteria for hazardous characteristics in soil. Land disposal restrictions may be applicable if sufficient concentrations of particular hazardous wastes identified in 40 CFR 268 are stored onsite. Missouri is an authorized state under RCRA, and Missouri state regulations replace federal regulations. For those federal standards for which Missouri has not yet received authorization, federal regulations will apply; therefore, both state and federal regulations must be evaluated.
Solid Waste Disposal Act, as amended (42 USC 6901, at seq.); Land Disposal Restrictions (40 CFR 268, Subpart D); 51 FR 40572, 11/7/86; 52 FR 25760, 7/8/87; 55 Fr 22520, 6/1/90	Land	Certain identified wastes are restricted from placement in or on the land, including landfills, surface impoundments, waste piles.	Potentially applicable	The RCRA requirements for generations, transportation and storage of hazardous wastes are applicable because RCRA hazardous wastes have been detected at the SLDS in concentration above EPA criteria for hazardous characteristics in soil. Land disposal restrictions may be applicable if sufficient concentrations of particular hazardous wastes identified in 40 CFR 268 are stored onsite. Missouri is an authorized state under RCRA, and Missouri state regulations replace federal regulations. For those federal standards for which Missouri has not yet received authorization, federal regulations will apply; therefore, both state and federal regulations must be evaluated.

Table F-3 (Cont'd)

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart B, General Facility Standards	Waste treatment storage, or disposal	General requirements are established for facility location and inspection, waste compatibility determination, and worker training. Location requirements include (1) facilities must not be located within 61 m (200 ft) of a fault in which displacement has occurred in Holocene time (i.e., since the end of the Pleistocene) and (2) facilities located in a 100-year floodplain must be constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood.	Potentially applicable	The RCRA requirement for generation, transportation, and storage of hazardous wastes are applicable because RCRA hazardous wastes have been detected at the SLDS in concentrations above EPA criteria for hazardous characteristics in soil. Land disposal restrictions may be applicable if sufficient concentrations of particular hazardous wastes identified in 40 CFR 268 are stored onsite. Missouri is an authorized state under RCRA, and Missouri state regulations replace federal regulations. For those federal standards for which Missouri has not yet received authorization, federal regulations will apply; therefore, both state and federal regulations must be evaluated.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart C, Preparedness and Prevention; Subpart D, Contingency Plan and Emergency Procedures	Waste treatment storage, or disposal	Facilities must be designed, constructed, maintained, and operated to minimize the possibility of a fire, explosion, or any unplanned sudden or nonsudden release of hazardous waste (or constituents) to air, water, or surface water that could threaten human health or the environment. A contingency plan must be in place and emergency procedures must be implemented to minimize releases of hazardous wastes from a facility.	Potentially applicable	The RCRA requirement for generation, transportation, and storage of hazardous wastes are applicable because RCRA hazardous wastes have been detected at the SLDS in concentrations above EPA criteria for hazardous characteristics in soil. Land disposal restrictions may be applicable if sufficient concentrations of particular hazardous wastes identified in 40 CFR 268 are stored onsite. Missouri is an authorized state under RCRA, and Missouri state regulations replace federal regulations. For those federal standards for which Missouri has not yet received authorization, federal regulations will apply; therefore, both state and federal regulations must be evaluated.

Table F-3 (Cont'd)

Potential ARAR	Action	Requirements	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart E, Manifest System, Recordkeeping, and Reporting; Subpart F, Releases from Solid Waste Management Units; Subpart G, Closure and Post-Closure; Subpart H, Financial Requirements; Subpart K, Surface Impoundments; Subpart L, Waste Piles, Subpart M, Land Treatment; Subpart N, Landfills; Subpart O, Incinerators; Subpart P, Thermal Treatment; Subpart X, Miscellaneous Units	Waste treatment, storage, or disposal	Various requirements (e.g., for facility design, operation, and closure, as appropriate) are established for treatment, storage, and disposal of hazardous wastes.	Potentially applicable	The RCRA requirements for generations, transportation and storage of hazardous wastes are applicable because RCRA hazardous wastes have been detected at the SLDS in concentration above EPA criteria for hazardous characteristics in soil. Land disposal restrictions may be applicable if sufficient concentrations of particular hazardous wastes identified in 40 CFR 268 are stored onsite. Missouri is an authorized state under RCRA, and Missouri state regulations replace federal regulations. For those federal standards for which Missouri has not yet received authorization, federal regulations will apply; therefore, both state and federal regulations must be evaluated.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Land Disposal Restrictions (40 CFR 268, Subpart D); 51 FR 40572, 11/7/86; 52 FR 25760, 7/8/87; 55 Fr 22520, 6/1/90	Land	Certain identified wastes are restricted from placement in or on the land, including landfills, surface impoundments, waste piles.	Potentially applicable	The RCRA requirements for generations, transportation and storage of hazardous wastes are applicable because RCRA hazardous wastes have been detected at the SLDS in concentration above EPA criteria for hazardous characteristics in soil. Land disposal restrictions may be applicable if sufficient concentrations of particular hazardous wastes identified in 40 CFR 268 are stored onsite. Missouri is an authorized state under RCRA, and Missouri state regulations replace federal regulations. For those federal standards for which Missouri has not yet received authorization, federal regulations will apply; therefore, both state and federal regulations must be evaluated.

Table F-3 (Cont'd)

Potential ARAR	Action	Requirement	Preliminary Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.070), Storage of Radioactive Materials	Waste storage	Radioactive materials must be stored in a manner that will not result in the exposure of any person, during routine access to a controlled area, in excess of the limits identified in 19 CSR 20-10.040 (see related discussion in Table B.2); a facility used to store materials that may emit radioactive gases or airborne particulate matter must be vented to ensure that the concentration of such substances in the air does not constitute a radiation hazard; and provisions must be made to minimize the hazard to emergency workers in the event of a fire, or potential earthquake, flood, or windstorm.	Potentially applicable	These requirements may be applicable to storage of materials associated with the remedial action.
Hazardous Radioactive Mixed Waste Program (DOE Order 5400.3)	Mixed waste management	The hazardous waste component of hazardous and radioactive mixed wastes should be managed according to the requirements of the Solid Waste Disposal Act, as amended, and the radioactive component of radioactive mixed waste should be managed according to the requirements of DOE Order 5820.2A (see related discussion in this table). Waste minimization measures should a so be implemented.	To be considered	Although not promulgated standards, these constitute requirements with which the proposed action will comply if material generated by the action meets the perquisites for definition as hazardous waste; in this case, the substantive storage requirements of the act would be addressed.

APPENDIX G

SOIL TESTING DATA FOR THE SLAPS/BALL FIELD PROPERTIES

Table G

Soil Testing Data for the SLAPS/Ball Field Properties

Boring[a]	Depth Top (ft)	Depth Bottom (ft)	Unit	Atterberg Limits Liquid Limit	Atterberg Limits Plastic Limit	Atterberg Limits Plasticity Index	Density (lb/ft^3)	Dry Specific Gravity	Water Content (%)	Void Ratio	Gradation Sand (%)	Gradation Fines[b] (%)	Uranium Distribution Ratio (ml/gm)	Effective Cation Exchange Capacity (meq/100 gm soil)	Laboratory Vertical Permeability (cm/s)
A-1	20.5		3T												5×10^{-6}
A-1	27.5		3T	40	21	19									2×10^{-8}
A-3	15.5		2	32	25	7	84.3	2.63							8×10^{-7}
A-5	26.5		3T	31	22	9									9×10^{-7}
B-2	16.5		2				90.7		29.5	0.823					2×10^{-4}
B-2	29.0		3T				95.6		27.6	0.730					7×10^{-6}
B-2	41.5		3T				91.2		29.8	0.813					5×10^{-6}
B-2	49.0		3M				82.5		38.5	1.004					7×10^{-7}
B-2	66.5		4				88.0		32.4	0.879					2×10^{-6}
B-2	79.0		4				96.2		24.7	0.719					8×10^{-6}
P-2	69.5		4	29	24	5									8×10^{-7}
P-2	83.5		4												2×10^{-8}
P-4	20.5		2	33	23	10	90.7	2.66							2×10^{-7}
G10-17	52.0	54.0	3M	70	25	45		2.34	23		15	85	11	223	
G12-12	49.5	51.5	3M	70	26	44		2.38	29		5	95	8.1	214	
G13-10	45.0	47.0	3M	70	28	42		2.35	28		1	99	8	187	
M13.5-8.5D	36.0	38.0	3T	30	21	9		2.31	22		6	94	11	150	
G11-2?	31.0	33.0	3T	39	19	20		2.40	25		17	83		144	
M10-15D	80.0	82.0	4	26	NP[c]	NP		2.38	29		20	80			
M13.5-8.5D	52.0	54.0	3M	43	20	23		2.32	32		12	88			
M11-21	10.0	12.0	2	30	25	5		2.33	25		31	69			
M10-8D	53.0	55.0	3B	29	23	6		2.53	27		13	87			
M10-8S	18.0	20.0	2	35	NP	NP		2.34	26		9	91			
G10-21	30.0	32.0	3T	27	NP	NP		2.42	23		3	97			
G10-29	27.0	29.0	3T	37	20	17		2.27	26		10	90			
G10-12	10.0	12.0	2	31	24	7		2.46	26		13	87			
M10-25D	28.5	30.5	3T	38	15	23		2.47	23		7	93			
M11-9	22.5	24.5	2	31	NP	NP		2.36	38		26	64			
G13-10	17.0	19.0	2	27	26	1		2.38	26		6	94			
M13.5-8.5S	22.0	24.0	2	37	NP	NP		2.57	38		19	81			
M10-15S	12.0	17.0	2	32	23	9		2.59	25		19	81			
G12-12	34.0	36.0	2					2.66	24		14	86			
M10-8D	33.1	33.3	3T	37	14	23		2.42	26		5	95			
G10-10	36.5	37.3	3T	29	23	6		2.35	13		6	94			
G10-12	32.9	33.6	3T	30	21	9		2.37	19		7	93			

Table G

(continued)

Boring[a]	Depth Top (ft)	Depth Bottom (ft)	Unit	Atterberg Limits Liquid Limit	Atterberg Limits Plastic Limit	Atterberg Limits Plasticity Index	Density (lb/ft^3)	Dry Specific Gravity	Water Content (%)	Void Ratio	Gradation Sand (%)	Gradation Fines[b] (%)	Uranium Distribution Ratio (ml/gm)	Effective Cation Exchange Capacity (meq/100 gm soil)	Laboratory Vertical Permeability (cm/s)
G10-17	20.7	21.0	2	27	24	3		2.41	19		12	88			
M10-25D	48.5	49.2	3T	37	21	16		2.38	29		10	90			
M13.5-8D	61.1	61.8	3B	30	22	8		2.57	22		15	85			
G14-24	33.5	34.0	3M	59	23	36		2.52	12		18	82			
M10-8D	46.0	46.8	3M					2.31	20		6	94			
M10-8D	68.0	70.0	3B					2.60	17		30	70			
M10-15D	86.4	87.1	4					2.21	12		44	56			
G10-17	28.2	28.8	3T					2.46	14		12	88			
G10-21	27.5	27.8	3T	39	19	20		2.31	18		10	90			
G10-21	39.0	39.3	3M					2.26	8		12	88			
G10-21	42.9	43.7	3M					2.27	25		6	94			
M10-25S	20.0	20.3	2					2.29	20		37	63			
M10-25D	37.0	37.5	3M					2.33	21		14	86			
G10-29	20.5	20.8	2	32	22	10		2.41	14		8	92			
M10-25S	13.5	13.8	1					2.33	26		52	48			
G12-8A	26.3	26.5	3T					2.44	10		32	68			
G12-12	39.9	40.4	3M					2.37	14		5	95			
G12-12	43.3	43.6	3M					2.34	26		11	89			
M12.5-8.5D	70.0	71.3	3B					2.35	18		15	85			
M13.5-8.5D	72.4	73.2	3B					2.53	14		31	69			
G14-12	16.4	16.6	1	25	23	1		2.46	21		22	78			
G14-12	21.7	21.9	2					2.36	3		9	91			
B53G18	8.0	13.0	2	36	23	13		2.54	22						
B53G06	0.0	2.5	2	34	20	14			18						
B53G06	2.5	7.5	2	35	22	13			21						
B53G06	13.5	18.5	2	33	21	12			24						
B53G06	18.5	23.5	2	40	28	12			27						
B53G06	28.5	33.5	3T	31	20	11			25						
B53G06	45.5	48.5	3M	77	26	51			37						
B53W02S	0.0	4.0	2	51	23	28			24						
B53W02S	4.8	9.0	2	37	18	19			22						
B53W02S	14.0	19.0	2	33	20	13			22						
B53W02S	19.5	22.0	3T	28	17	11			20						
B53W02D	44.0	49.0	3M	78	26	52			29						
B53W02D	59.0	64.0	3B	32	20	12			25						

Table G

(continued)

Boring[a]	Depth Top (ft)	Depth Bottom (ft)	Unit	Atterberg Limits Liquid Limit	Atterberg Limits Plastic Limit	Atterberg Limits Plasticity Index	Density (lb/ft^3)	Dry Specific Gravity	Water Content (%)	Void Ratio	Gradation Sand (%)	Gradation Fines[b] (%)	Uranium Distribution Ratio (ml/gm)	Effective Cation Exchange Capacity (meq/100 gm soil)	Laboratory Vertical Permeability (cm/s)
B53G01	18.0	20.0	2				102.9		26	0.528					8.8×10^{-7}
B53G02	54.0	56.0	3M				97.3		28	0.501					5.9×10^{-8}
B53G03	28.0	30.0	3T				102.4		24	0.475					1.6×10^{-6}
B53G04	29.0	31.0	3T				83.2		31	0.815					2.7×10^{-7}
B53G05	49.0	51.0	3M				70.5		50	1.071					1.4×10^{-8}
B53G06	43.5	45.5	3M				79.0		39	0.848					1.6×10^{-8}
B53G07	10.0	13.5	2										35.2	122	
B53G10	9.5	14.0	2										329.3	184	
B53W10S	8.5	13.5	2										126.7	200	
B53W10D	9.5	14.0	2										329.3	142	
B53G12	38.5	40.5	3T				94.4		26	0.600					1.8×10^{-6}
B53G13	29.0	31.0	2				102.5		24	0.534					1.4×10^{-8}
B53G13	49.0	51.0	3T				95.7		31	0.578					9.0×10^{-7}
B53W14S	14.5	18.5	2										19.1	98	
B53G18	58.0	68.0	3B				99.5		29	0.518					1.7×10^{-7}
B53G15	13.5	18.5	2	33	23	10		2.63	24		2	98			
B53G18	8.0	13.0	2	36	23	13		2.54	22		1	99			
B53W13S	9.5	14.5	2	39	24	15		2.59	28		5	95			
B53W11D	15.5	18.5	3T	36	22	14			23		5	95			
B53W11D	4.5	9.5	2	36	23	13		2.63	25		3	97			
B53G18	43.0	48.0	3M	78	28	50			32		0	100			
B53G18	25.0	28.0	3T	37	19	18			25		1	99			
B53G18	13.0	18.0	2	33	23	10		2.58	21		0	100			
B53G17	36.0	38.0	3B	29	25	4			19		1	99			
B53G17	19.5	23.0	3T	42	19	23			28		0	100			
B53G17	13.0	18.0	2	39	22	17		2.56	27		0	100			
B53G16	13.5	18.5	2	32	25	7		2.57	27		0	100			
B53G11	34.5	39.5	3T	29	21	8			22		0	100			
B53G11	19.5	24.5	2	34	23	11		2.61	23		0	100			
B53G09	53.0	58.0	3B	53	20	33			27		1	99			
B53G08	14.5	17.0	2	32	24	8		2.51	23		2	98			
B53G14	28.5	32.0	3T	46	81	25			26		3	97			
B53G14	23.5	28.5	3T	35	22	13			25		0	100			
B53G14	8.5	13.5	2	36	24	12		2.44	22		0	100			
B53G13	89.0	94.0	4						16		77	23			

Table G

(continued)

Boring[a]	Depth Top (ft)	Depth Bottom (ft)	Unit	Atterberg Limits Liquid Limit	Atterberg Limits Plastic Limit	Atterberg Limits Plasticity Index	Density (lb/ft^3)	Dry Specific Gravity	Water Content (%)	Void Ratio	Gradation Sand (%)	Gradation Fines[b] (%)	Uranium Distribution Ratio (ml/gm)	Effective Cation Exchange Capacity (meq/100 gm soil)	Laboratory Vertical Permeability (cm/s)
B53G13	9.0	13.5	2	32	22	10		2.53	24		14	86			
B53G12	40.5	43.5	3B	31	19	12			25		25	75			
B53G03	49.0	54.0	3M	71	26	45			21		0	100			
B53G03	64.0	69.0	3B	33	20	13			20		7	93			
B53G12	23.5	28.5	3T	40	18	22			28		5	95			
B53G12	8.5	13.5	2	33	23	10		2.62	26		4	96			
B53G03	23.0	28.0	3T	29	21	8			20		7	93			
B53G03	3.0	8.0	2	34	24	11		2.73	24		2	98			

NOTE: Blank spaces indicate no data or data not available.

[a]See Figure 3-1 for borehole locations.

[b]Fines = percent of sample finer than the No. 200 sieve (0.074 mm).

[c]NP = nonplastic.

APPENDIX H

CONTRACTOR DISCLOSURE STATEMENT

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF EIS PORTION OF ST. LOUIS SITE FUSRAP PROPOSED ACTION

CEQ Regulations at 40 CFR 1506.5(c), which have been adopted by the DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for purposes of this disclosure is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations", 46 FR 18026-18038 at Question 17a and b.

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)". 46 FR 18026-18038 at 18031.

In accordance with these requirements, Science Applications International Corporation hereby certifies as follows: check either (a) or (b),

(a) Science Applications International Corporation (COMPANY NAME) has no financial or other interests in the outcome of the St. Louis Site FUSRAP Feasibility Study/Environmental Impact Statement Activities.

(b) _____ (COMPANY NAME) has the following financial or other interest in the outcome of the St. Louis Site FUSRAP Feasibility Study/ Environmental Impact Statement Activities and hereby agree to divert itself of such interest prior to including any technical analyses in support of this Project.

Financial or Other Interests

1.

2.

3.

Certified by:

Betty M. Bidwell
SIGNATURE

Betty Bidwell
NAME

Group Contracts Manager
TITLE

July 27, 1993
DATE

ST. LOUIS DOWNTOWN SITE
ADMINISTRATIVE RECORD
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9808171015	MDNR Comments on the St. Louis FUSRAP Site Remedial Investigation Report	MDNR	USDOE – Oak Ridge	Vol. 3e	9/91
9808171009	USEPA Region VII Comments on St. Louis Site Remedial Investigation Report	USEPA –Region VII	USDOE – Oak Ridge	Vol. 3e	11/91
9808201028	St. Louis Downtown Site Buildings with Access-Restricted Soils	USDOE – Oak Ridge	Mallincrodt	Vol. 3e	4/93
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