FINAL

SAMPLING AND ANALYSIS GUIDE FOR THE ST. LOUIS SITES

ST. LOUIS, MISSOURI

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ACRONYMS AND ABBREVIATIONS

Ac	actinium
AEC	United States Atomic Energy Commission
amsl	above mean sea level
As	arsenic
ASTM	American Society for Testing and Materials
Ba	barium
bgs	below ground surface
Cl_2	chloride
CAS	Chemical Abstract Services
Cd	cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
cm	centimeter
CME	central mine equipment
COC	contaminants of concern
COPC	contaminants of potential concern
CP	contiguous property
cpm	counts per minute
CQC	Chemical Quality Control
CSR	Code of State Regulations
CX	Center of Excellence
DCE	dichloroethene
DCGL	derived concentration guideline levels
DMPP	Data Management Program Plan
DOD	Department of Defense
DOE	United States Department of Energy
DOT	United States Department of Transportation
DQCR	data quality control reports
DQO	data quality objective
EE/CA	Engineering Evaluation/Cost Analyses
EM	electromagnetic
EMG	Environmental Monitoring Guide
EMI	Environmental Monitoring Implementation
EML	Environmental Measurements Laboratory
EPA	United States Environmental Protection Agency
FCO	Field Change Order
Fe	iron
FFA	Federal Facilities Agreement
FID	flame ionization detectors
FOM	Field Operations Manager
FS	Feasibility Study
ft	feet

ACRONYMS AND ABBREVIATIONS (CONT'D)

FUSRAP	Formerly Utilized Sites Remedial Action Program
GC	gas chromatography
GFAA	graphite furnace atomic absorption
GPR	ground-penetrating radar
GPS	global positioning system
GWS	gamma walkover survey
ha	hectare
HISS	Hazelwood Interim Storage Site
HPGe	High Purity Germanium
HTRW	Hazardous, Toxic, and Radioactive Waste
HU	hydrostratigraphic units
HZ	hydrostratigraphic zone
IA	investigation area
ICP	inductively coupled plasma
IDW	investigative-derived wastes
in.	inch(es)
km	kilometer
L	liter
LCS	laboratory control sample
LOR	Letter-of-Receipt
m	meters
M&TE	measuring and testing equipment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	maximum contaminant level
MCPA	2-methyl-4-chlorophenoxy acetic acid
MCPP	2-(2-methyl-4-chlorophenoxy) propionic acid
MDA	minimum detectable activities
MDL	maximum detection limits
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineering Districts
mg/kg	milligram per kilogram
mg/L	milligrams per liter
mi.	miles
mm	millimeters
Mn	manganese
MS	matrix spike
MSD	matrix spike duplicate
NAPL	non-aqueous phase liquid
NCR	nonconformance report
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List

ACRONYMS AND ABBREVIATIONS (CONT'D)

NRC	Nuclear Regulatory Commission
NTU	nephelometric turbidity units
OSHA	Occupational Safety and Health Administration
OVA	organic vapor analyzer
Pa	protactinium
PCB	polychlorinated biphenyl
pCi/g	picocuries per gram
pCi/L	picocuries per liter
PCOC	potential constituent of concern
PID	photoionization detectors
PM_{10}	micron particulate material
PPE	personal protective equipment
ppm	parts per million
PQL	practical quantitation limits
PRG	preliminary remediation goal
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Program Plan
QC	quality control
QCSR	Quality Control Summary Report
Ra	radium
RAS	Routine Analytical Services
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	Record of Decision
RPD	relative percent difference
RSD	relative standard deviation
SAG	Sampling and Analysis Guide
SAIC	Science Applications International Corporation
SAS	Statistical Analysis System
SDG	Sample Delivery Group
SLAPS	St. Louis Airport Site
SLDEIMS	St. Louis District Environmental Information Management System
SLDS	St. Louis Downtown Site
SLS	St. Louis Sites
SMCL	secondary maximum contaminant level
SO_4	sulfate
SOP	standard operating procedure
SOW	Statement of Work
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
SVOC	semi-volatile organic compound
TAL	target analyte list
TCE	trichloroethene

ACRONYMS AND ABBREVIATIONS (CONT'D)

TCLP	toxicity characteristic leaching procedure
TDF	Technical Direction Form
Th	thorium
TIC	tentatively identified compound
TLD	thermoluminescent dosimeter
TOX	total organic halides
TPH	total petroleum hydrocarbons
TSP	total suspended particulate
U	uranium
USACE	United States Army Corp of Engineers
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
VP	vicinity property
WD	work descriptions
yd^3	cubic yards
°C	degrees Centigrade
µg/L	microgram per liter
µm	micrometers

1.0 INTRODUCTION

The St. Louis Sampling and Analysis Guide (SAG) was prepared to provide a single source document to guide sampling and analysis activities conducted under the Formerly Utilized Sites Remedial Action Program (FUSRAP) at the St. Louis Sites (SLS). This document provides a compendium of procedures, protocols and methodologies, which may be used in preparing site-specific Work Descriptions (WDs). By using the methodologies, quality assurance and data management standards described in this guidance document, consistency and comparability of sampling results will be maintained for the SLS.

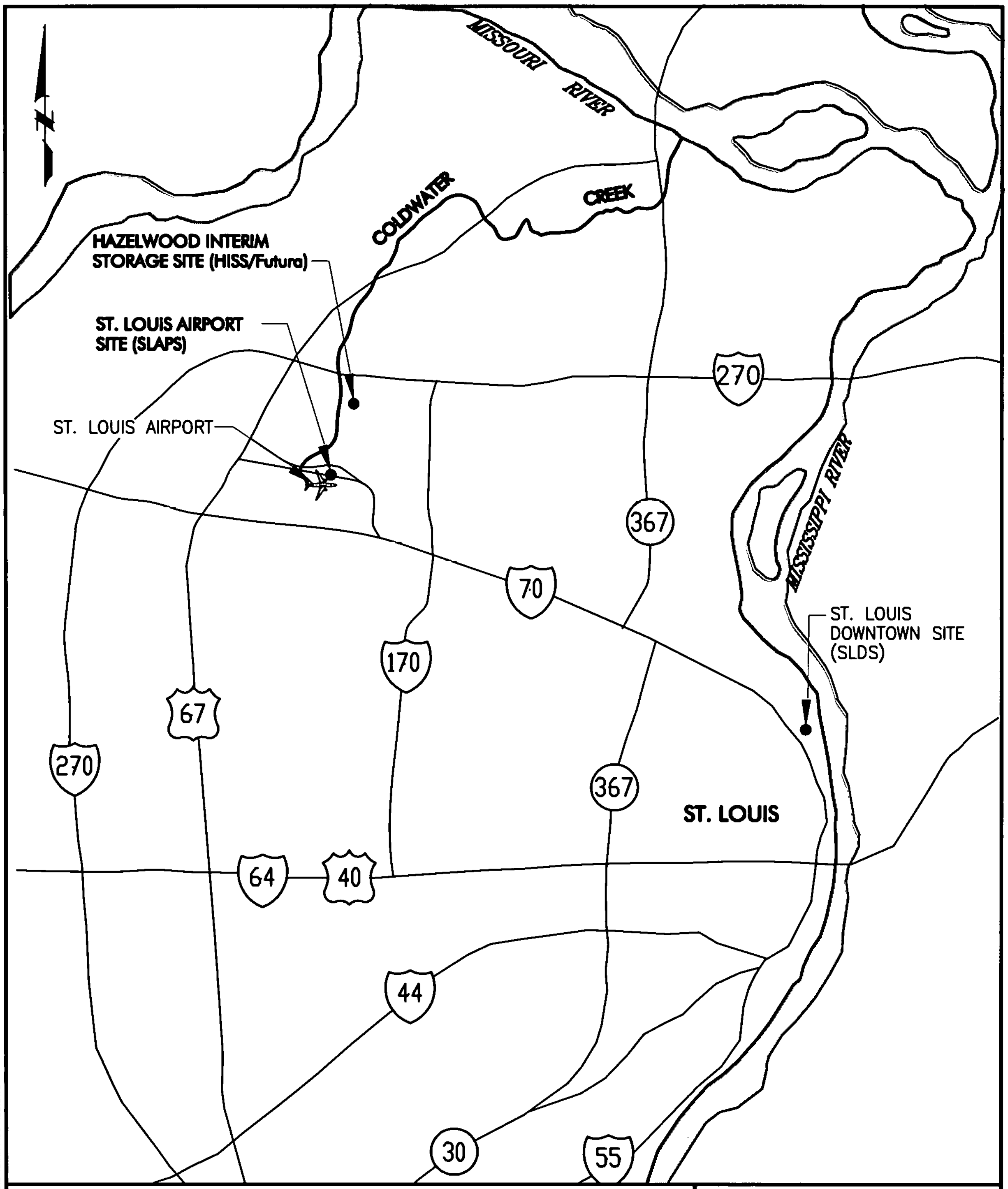
1.1 Purpose/Authority

This document provides the guidelines necessary to perform sampling activities at any of the St. Louis FUSRAP Sites and will aid in developing appropriate data quality objectives (DQOs), and monitoring requirements for each particular area. FUSRAP was initiated to identify and remediate contamination or otherwise control sites where residual radioactivity remains from activities conducted under contracts to the Manhattan Engineering District (MED) and the United States Atomic Energy Commission (AEC) or from commercial operations that Congress has added to the FUSRAP Sites. FUSRAP was transferred from the Department of Energy (DOE) to the United States Army Corps of Engineers (USACE). The USACE has the authority to characterize and remediate contaminants associated with the historical AEC facilities that supported the nations early nuclear defense related activities. A Federal Facilities Agreement (FFA) negotiated by the United States Environmental Protection Agency (EPA) Region VII and the DOE outlines those responsibilities (DOE, 1990a). The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) also governs remedial efforts on specific FUSRAP Sites. The Missouri Department of Natural Resources (MDNR) also provides regulatory reviews of the ongoing remedial efforts at the SLS of FUSRAP.

1.2 Scope of the Guide

The document defines procedures for SLS sampling activities at the various sites. These sites include the St. Louis Downtown Site (SLDS) and vicinity properties (VPs), the St. Louis Airport Site (SLAPS) and contiguous properties (CPs), SLAPS VPs/Haul Roads, the Hazelwood Interim Storage Site (HISS) and Latty Avenue VPs, and Coldwater Creek. The locations of these sites are shown on Figure 1-1.

In addition, this document contains a Quality Assurance Program Plan (QAPP) that provides the organization, functional objectives, and general Quality Assurance/Quality Control (QA/QC) requirements associated with sample collection for these sites. A Data Management Program Plan (DMPP) describes the process used for planning, collection, tracking, verification, validation, analysis, presentation, and storage of data collected at the SLS of FUSRAP.



St. Louis North County Site: SLAPS, HISS/Futura, and Coldwater Creek Vicinity Properties not shown

FUSRAP

St. Louis Airport Sites
Location of FUSRAP Properties
St. Louis, Missouri

DRAWN BY:	REV. NO./DATE:
S. Kitchings	06/01/00

Figure 1-1. St. Louis Formerly Utilized Sites Remedial Action Program Location Map

Before initiation of a particular field activity, a WD will be generated and approved by the USACE. The WD is a task- or site-specific sampling and analysis plan or field sampling plan which may reference this manual for specific sampling methodologies, QA/QC, and data management guidance. The WD will identify the specific data and sampling needs. It will provide a summary of the current conditions, and applicable background information to support the task-specific DQOs. The media-specific parameters, location, depths, number of samples, QA/QC samples to be analyzed, et cetera must also be identified in each WD. Other documents and procedures not provided in this SAG may be incorporated by reference or attached to the WD, if needed. Finally, the WD will include a schedule of field activities, and description of what, how, and when the information is reported.

Some documents, including task specific health and safety plans, radiation safety and health plans and handling of investigation derived waste (IDW), are generated on a task- or contractor-specific basis. Guidance for the preparation and use of these plans is also identified within this document.

1.3 Organization

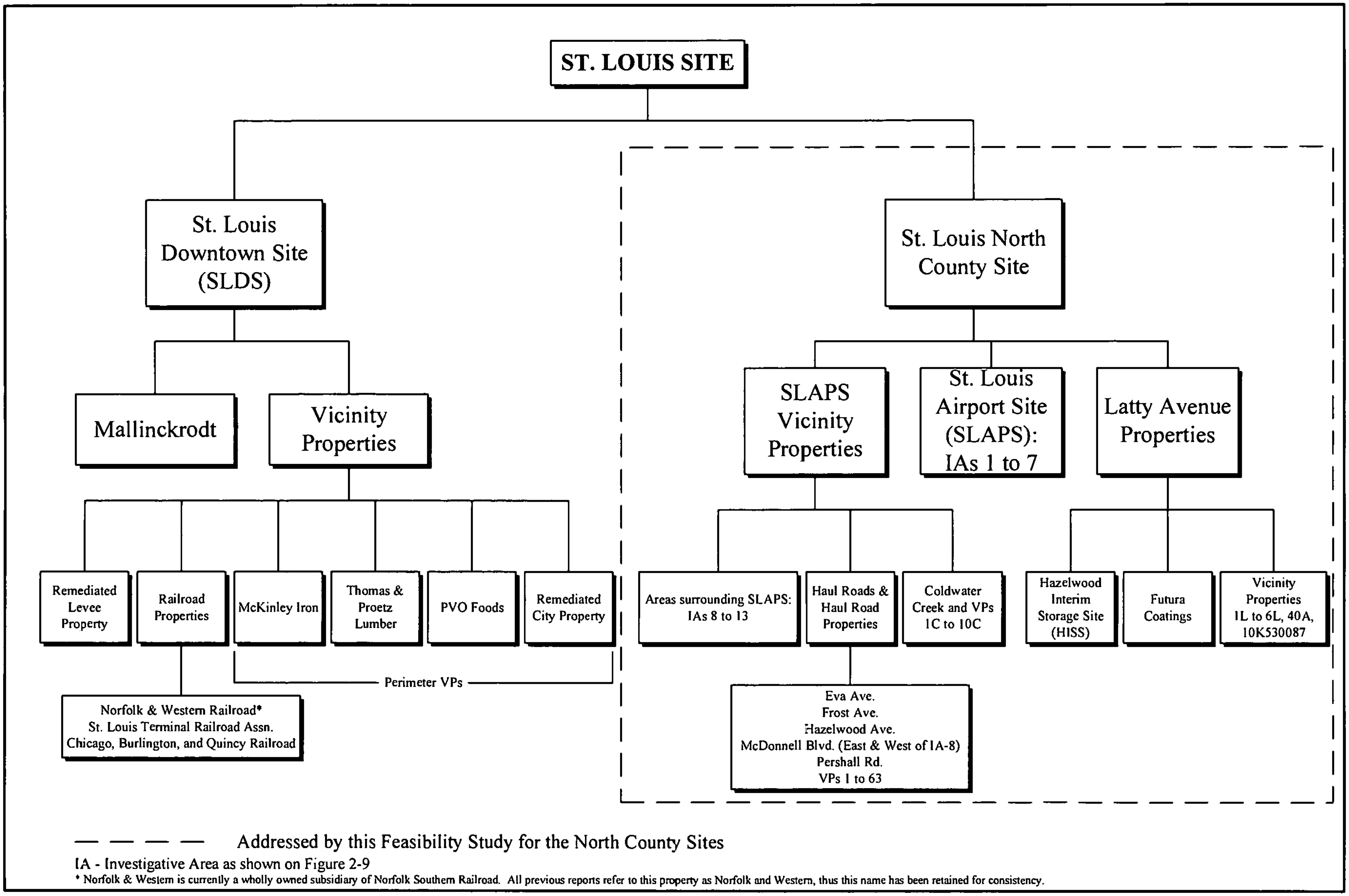
The SAG is organized into sections to facilitate access. In order to efficiently reference various methodologies, section numbers should be included when preparing work descriptions. A description of the SAG organization is as follows:

- Section 1 contains an overview of the purpose, authority, scope, organization and objectives of the SAG.
- Section 2 describes field investigation approaches and protocols for selected media sampling activities.
- Section 3 provides the overall Quality Assurance guidance for the SLS.
- Section 4 presents guidance for overall data management at the SLS.
- Section 5 identifies general IDW guidance for the SLS.
- Section 6 identifies general health and safety guidance for the SLS.
- Section 7 provides a detailed bibliography and reference list for the SLS.

1.4 Site Descriptions and Background

The St. Louis FUSRAP Sites are the SLDS, SLAPS, HISS, Coldwater Creek, and their associated adjacent property(ies) or VP locations that were involved with or impacted by the development of uranium processing techniques, production of uranium metal and compounds, uranium recovery from residues and scrap, and storage, transportation, and disposal of associated process byproducts. These activities were conducted under contract to the MED and AEC from the early 1940's until the mid 1960's. A schematic representation of the SLS is provided in Figure 1-2.

SLDS and SLAPS were among the first sites to be designated for remedial actions under FUSRAP. Congress, through the 1984 Energy and Water Development Appropriations Act, added HISS to FUSRAP. SLAPS and HISS were added to the EPA National Priority List (NPL) on October 4, 1989 [40 Code of Federal Regulations (CFR), Part 300, Appendix B]. Activities at



— — — — Addressed by this Feasibility Study for the North County Sites

IA - Investigative Area as shown on Figure 2-9

* Norfolk & Western is currently a wholly owned subsidiary of Norfolk Southern Railroad. All previous reports refer to this property as Norfolk and Western, thus this name has been retained for consistency.

Figure 1-2. Schematic Representation of the FUSRAP St. Louis Site these three sites and subsequent migration of contaminants have resulted in contamination of portions of properties contiguous to SLDS, SLAPS, and HISS; these areas have been designated as CPs or VPs and are included within the scope of historical site characterization activities and remedial decisions. Coldwater Creek has also been impacted from migration of contaminants from SLAPS and HISS. Numerous documents contain detailed descriptions of the sites and operational histories, in particular the remedial investigation (RI) work plan (DOE, 1991) and RI reports (DOE,1994a; DOE, 1995). Thus, the site histories presented below are limited to summary and recent characterization information.

1.4.1 SLDS and VPs

SLDS is located in an industrialized area on the eastern border of St. Louis, 91 meters (m) [300 feet (ft)] west of the Mississippi River and 18 kilometers (km) [11 miles (mi.)] southeast of the Airport Area (Figure 1-1). SLDS consists of the Mallinckrodt Chemical Works (Mallinckrodt Property), owned by Mallinckrodt, Inc. (Mallinckrodt), and VPs. The Mallinckrodt Property is bordered to the north by McKinley Iron Works, a large metal recycleing company; to the east by the Mississippi River, PVO Foods (abandoned), and property owned by the City of St. Louis; to the south by Thomas and Proctz Lumber; and to the west by Broadway Street. Additionally, the Norfolk and Western Railroad; the Chicago, Burlington, and Quincy Railroad; and the St. Louis Terminal Railroad Association have active rail lines passing in a north/south direction through the Mallinckrodt Property. An earthen levee between the river and SLDS protects the area from floodwaters. These commercial and city-owned properties are collectively referred to as SLDS VPs. Perimeter VPs include the City of St. Louis property, PVO Foods, McKinley Ironworks, and Thomas and Proetz Lumber Company. Manufacturing plants, support facilities, and administrative buildings cover a large portion of the site with the rest of the complex covered mostly with asphalt or concrete.

1.4.1.1 Operational History

SLDS is an active 18-hectare (ha) [45-acre] industrial property in eastern St. Louis. The majority of the property is owned by Mallinckrodt, Inc., which has used the property for chemical manufacturing since 1867. The industrial facility consists of multiple separate former and active production complexes (plants) and ancillary support buildings and offices (Figure 1-3).

SLDS and VPs have been used for industrial purposes for over a century. Between 1942 and 1957, the former Mallinckrodt Chemical Works performed work under contract to the MED and AEC at Plants 1, 2, 4, 6, 6E, 7, 7E, 7N, and 7S. The work included development of uranium processing techniques and production of uranium metal using various chemical processes and intermediates (nitric acid leaching, solvent extraction, fluorination using hydrofluoric acid, and reduction using magnesium). In addition, some facilities were used for metallurgical processing of uranium, storage of reactor cores, and uranium recovery from slag (DOE, 1990b).

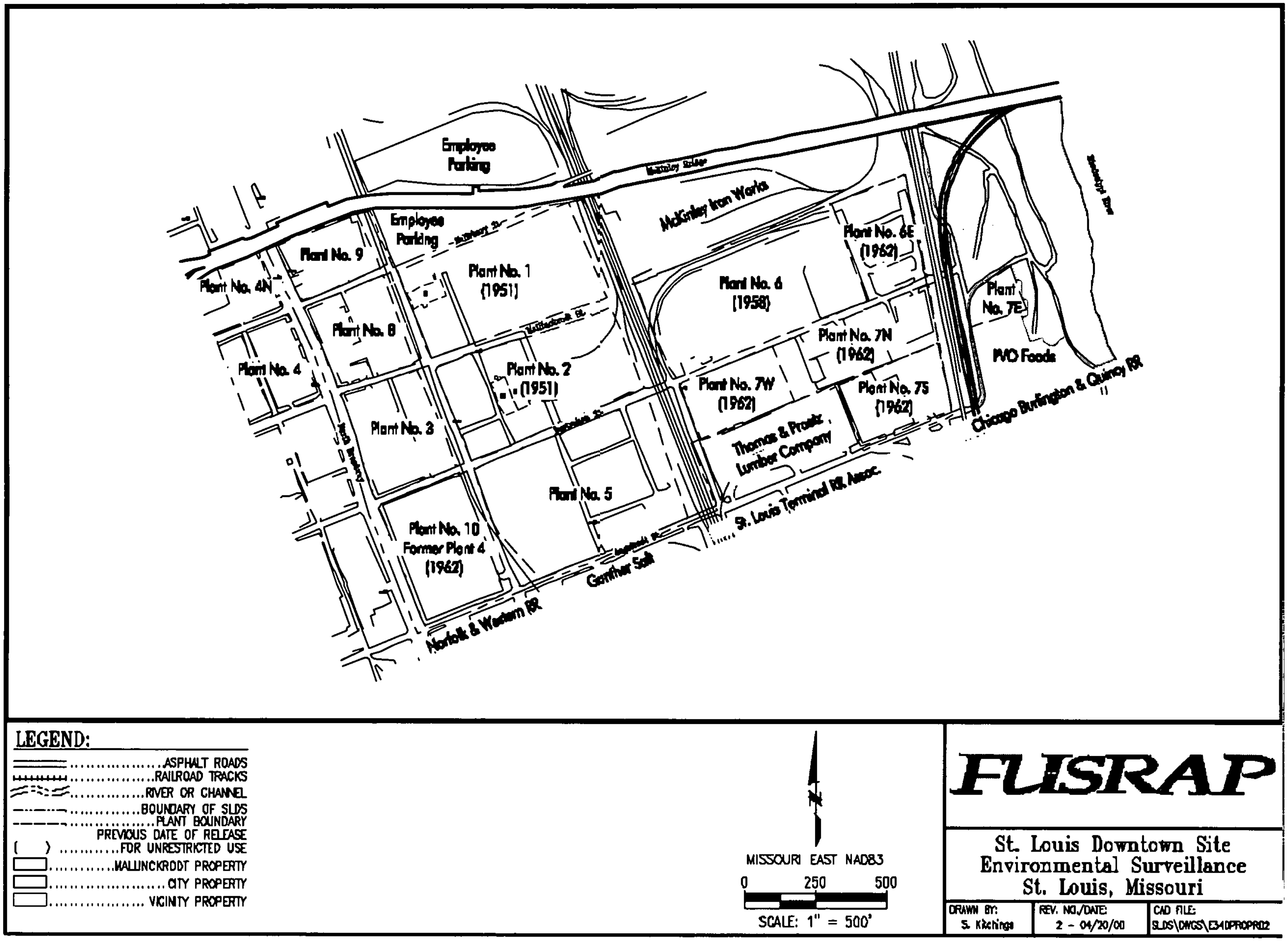


Figure 2-2. Plan View of SLDS

1.4.1.2 Waste Inventories

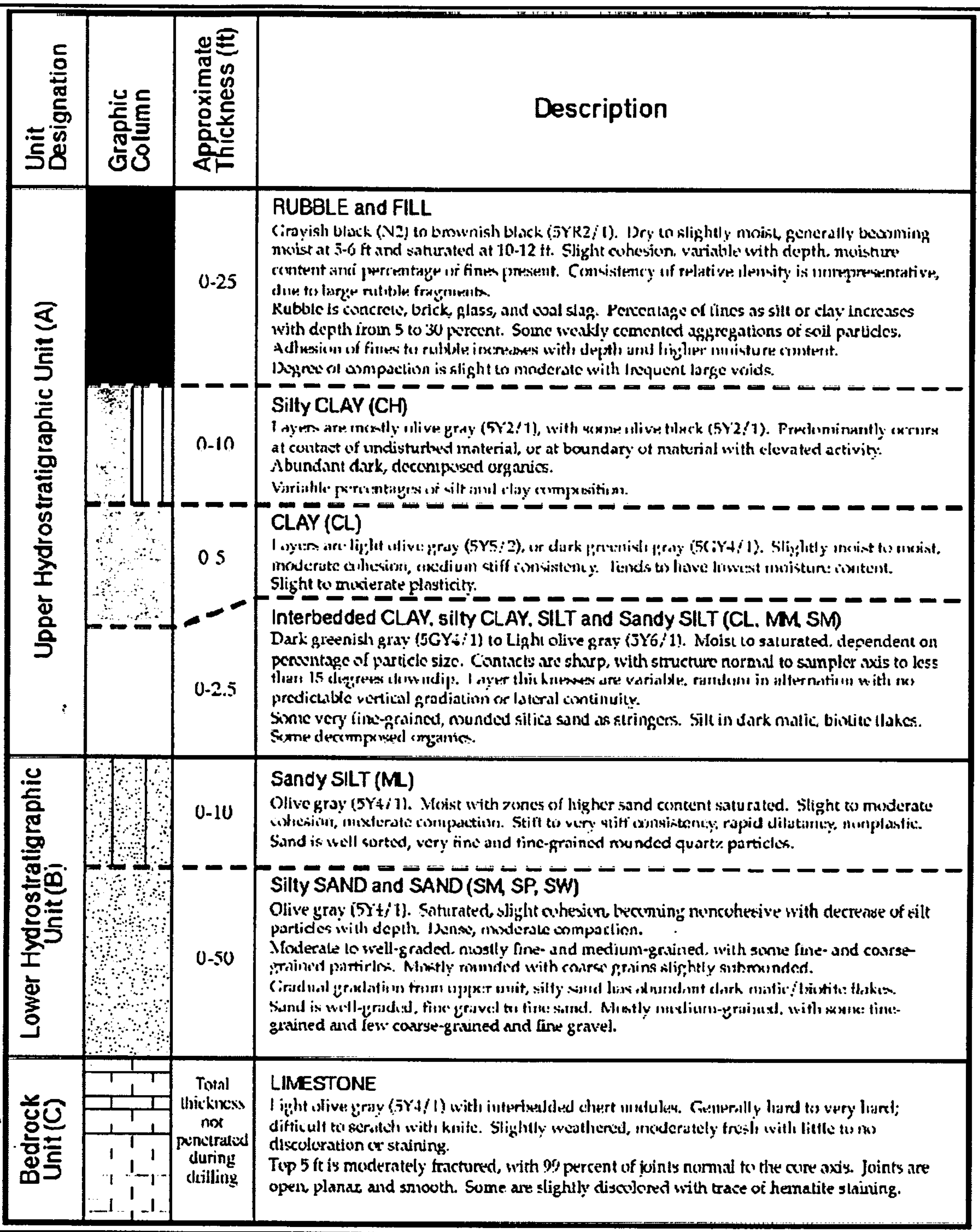
Byproducts from production activities at SLDS included spent pitchblende ore, process chemicals (primarily leached barium sulfate), and uranium, radium, and thorium-bearing residuals. The byproducts of the production activities of SLDS were staged or stored at various locations within the site for subsequent transport to SLAPS. Waste generation records are not available; estimated volumes of materials transported to SLAPS are discussed in subsequent sections. Demolition materials are sometimes temporarily stockpiled on the site as a result of interim remedial actions.

1.4.1.3 Site Characteristics

The topography of the area around St. Louis is typified by gently rolling hills in the uplands and steepwalled, broad [up to 16 km (10 mi) wide] river valleys. The SLDS is located near the western bank of the Mississippi River 21 km (13 mi) downstream of the Mississippi-Missouri confluence. The site is potected by a man-made levee and is flat due to extensive construction and grading. Industrial development has also oblitinated geologic features such as perennial streams and the soil column. Surface drainage is directed through drainage ditches and catchment basins into an extensive storm drain system that discharges to the Bissell Point Sewage Treatment Plant. All St. Louis area municipal water intakes are located upstream of the SLDS with the exception of the Illinois-American Water Plant intake which serves East St. Louis and is located about 13 km (8 mi.) downstream on the east bank of the river.

The St. Louis area is underlain by 1,829 m (6,000 ft) of cyclic deposition of Paleozoic sandstone, shale, limestone, and dolomite (Figure 1-4). The deposits thicken into the Illinois Basin to the east and toward the Ozark Dome to the southwest. They are nearly horizontal, dipping less than 1 degree to the northeast as a result of uplift of the Ozark Dome. The overlying Pleistocene and recent sediments and fill consist of sand, silt, and clay layers that typically range from less than 2 m (5 ft) to more than 30 m (100 ft) thick. The fill consists of cinders, bricks, soil, and other debris and has been placed on top of the original floodplain to depths of up to 9 m (30 ft) as the area has been developed. The naturally occurring surficial deposits originated from multiple sources including glacial outwash consisting of mixtures of clay, silts, and sand; wind-deposited loess; and deposits from the Mississippi and Missouri Rivers. The surficial sediments range in at depths from 6 m (19 ft) on the western side of the SLDS to 24 m (80 ft) near the Mississippi River.

Ground water at the SLDS is found within three horizons [or hydrostratigraphic units (HU)]: the upper unit, referred to as the HU-A (consisting of fill on top of clay and silt); the lower, alluvial unit, referred to as either the Mississippi Alluvial Aquifer or the HU-B; and the bedrock, referred to as the HU-C (Figure 1-5), (USACE, 1998a). The Mississippi Alluvial Aquifer is a principal aquifer in the St. Louis area, including the SLDS area. Aquifers in this region also exist in the bedrock formations underlying the alluvial deposits. Ground waters of the St. Louis area are generally of poor quality and do not meet drinking water standards without treatment. Expected future use of ground water at the SLDS is minimal, because the higher quality and large quantity of the Mississippi and Missouri Rivers is readily available.



Unit Designation	Graphic Column	Approximate Thickness (ft)	Description
Upper Hydrostratigraphic Unit (A)		0-25	RUBBLE and FILL Grayish black (N2) to brownish black (5YR2/1). Dry to slightly moist, generally becoming moist at 5-6 ft and saturated at 10-12 ft. Slight cohesion, variable with depth, moisture content and percentage of fines present. Consistency of relative density is unrepresentative, due to large rubble fragments. Rubble is concrete, brick, glass, and coal slag. Percentage of fines as silt or clay increases with depth from 5 to 30 percent. Some weakly cemented aggregations of soil particles. Adhesion of fines to rubble increases with depth and higher moisture content. Degree of compaction is slight to moderate with frequent large voids.
		0-10	Silty CLAY (CH) Layers are mostly olive gray (5Y2/1), with some olive black (5Y2/1). Predominantly occurs at contact of undisturbed material, or at boundary of material with elevated activity. Abundant dark, decomposed organics. Variable percentages of silt and clay composition.
		0 5	CLAY (CL) Layers are light olive gray (5Y5/2), or dark greenish gray (5GY4/1). Slightly moist to moist, moderate cohesion, medium stiff consistency. Tends to have lowest moisture content. Slight to moderate plasticity.
		0-2.5	Interbedded CLAY, silty CLAY, SILT and Sandy SILT (CL, MM, SM) Dark greenish gray (5GY4/1) to Light olive gray (5Y6/1). Moist to saturated, dependent on percentage of particle size. Contacts are sharp, with structure normal to sampler axis to less than 15 degrees downdip. Layer thicknesses are variable, random in alternation with no predictable vertical gradation or lateral continuity. Some very fine-grained, rounded silica sand as stringers. Silt in dark matic, biotite flakes. Some decomposed organics.
Lower Hydrostratigraphic Unit (B)		0-10	Sandy SILT (ML) Olive gray (5Y4/1). Moist with zones of higher sand content saturated. Slight to moderate cohesion, moderate compaction. Stiff to very stiff consistency, rapid dilatancy, nonplastic. Sand is well sorted, very fine and fine-grained rounded quartz particles.
		0-50	Silty SAND and SAND (SM, SP, SW) Olive gray (5Y4/1). Saturated, slight cohesion, becoming noncohesive with decrease of silt particles with depth. Dense, moderate compaction. Moderate to well-graded, mostly fine- and medium-grained, with some fine- and coarse-grained particles. Mostly rounded with coarse grains slightly subrounded. Gradual gradation from upper unit, silty sand has abundant dark matic/biotite flakes. Sand is well-graded, fine gravel to fine sand. Mostly medium-grained, with some fine-grained and few coarse-grained and fine gravel.
Bedrock Unit (C)		Total thickness not penetrated during drilling	LIMESTONE Light olive gray (5Y4/1) with interbedded chert nodules. Generally hard to very hard; difficult to scratch with knife. Slightly weathered, moderately fresh with little to no discoloration or staining. Top 5 ft is moderately fractured, with 99 percent of joints normal to the core axis. Joints are open, planar, and smooth. Some are slightly discolored with trace of hematite staining.

SOURCE: MODIFIED FROM BNI 1992.
NOTE: THE CODES IN PARENTHESES FOLLING LITHOLOGIES ARE THE UNIFIED SOIL CLASSIFICATION SYSTEMS CODES.

NOT TO SCALE

FUSRAP

St. Louis Downtown Site
Environmental Surveillance
St. Louis, Missouri

DRAWN BY:	REV. NO./DATE:	CAD FILE:
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Figure 5-8. Generalized Stratigraphic Column for SLDS

The HU-A is heterogeneous and the youngest of the three hydrostratigraphic units. The unit overlies the HU-B on the east and bedrock on the west at the SLDS. The HU-A has the largest range of constituents and thus a wide variation of spatial hydraulic conductivity. This uppermost unit does not have water levels or flow directly related to the river stage. The base of the HU-A consists of fine-grained deposits behind the Mississippi River's natural levee. The HU-A also had meandering creeks and swampy low topography prior to the introduction of fill material. In the 1800's the HU-A's surface was raised with the least expensive, most readily available fill materials: rubble and wood and coal combustion wastes, e.g., coal slag and cinders. The combustion products used for fill had inherently high metal concentrations. Infiltration of water in the HU-A is relatively minor, because the ground surface has large areas of buildings, road surfacing, and channeled surface water flow. This shallow unit is not a productive source of water due to poor yield and its multiple chemical constituents. The HU-A is not an aquifer and is not considered a potential source of drinking water because it has insufficient yield, poor natural water quality, and susceptibility to surface water contaminants from the industrial setting.

Hydrostratigraphic Unit B ranges in thickness from 21 m (70 ft) just east of the Mississippi River to absent near the western boundary of the SLDS. The ancestral Mississippi River deposited the unit after the river's greatest erosion of the bedrock floor. The unit is made up of repward-fining, interfingered, crossent sands that are hydrautically connected to the Mississippi River. The granular nature and association with the river allows the HU-B to have unique chemical and hydraulic character. The HU-B has high dissolved solids and metal concentrations [iron and manganese above their secondary maximum contaminant levels (SMCLs)]. The dissolved solids and metal content are naturally occurring.

The aquifer's pressure and flow direction react to changing river stages. Fluid pressure and flow direction in the Mississippi Alluvial Aquifer responds directly to the river's stages. When the river is at low stage, recharge to the aquifer is from the higher pressured limestone below HU-B or from downward infiltration from HU-A and flow in toward the river. At high river stages or during heavy pumping, recharge is from the hydrautically connected river and flow in the aquifer is directed away from the river.

Extracted water from the HU-B would require treatment to reduce the natural total dissolved solid and metal content. The use of the HU-B for a drinking water resource is highly unlikely for several reasons: the industrial setting of the SLDS, the site's proximity to both the Mississippi and the city's drinking water supply, and the poor natural water quality of the HU-B. However, the HU-B does qualify as a potential source of drinking water under the Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy (EPA, 1986b).

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

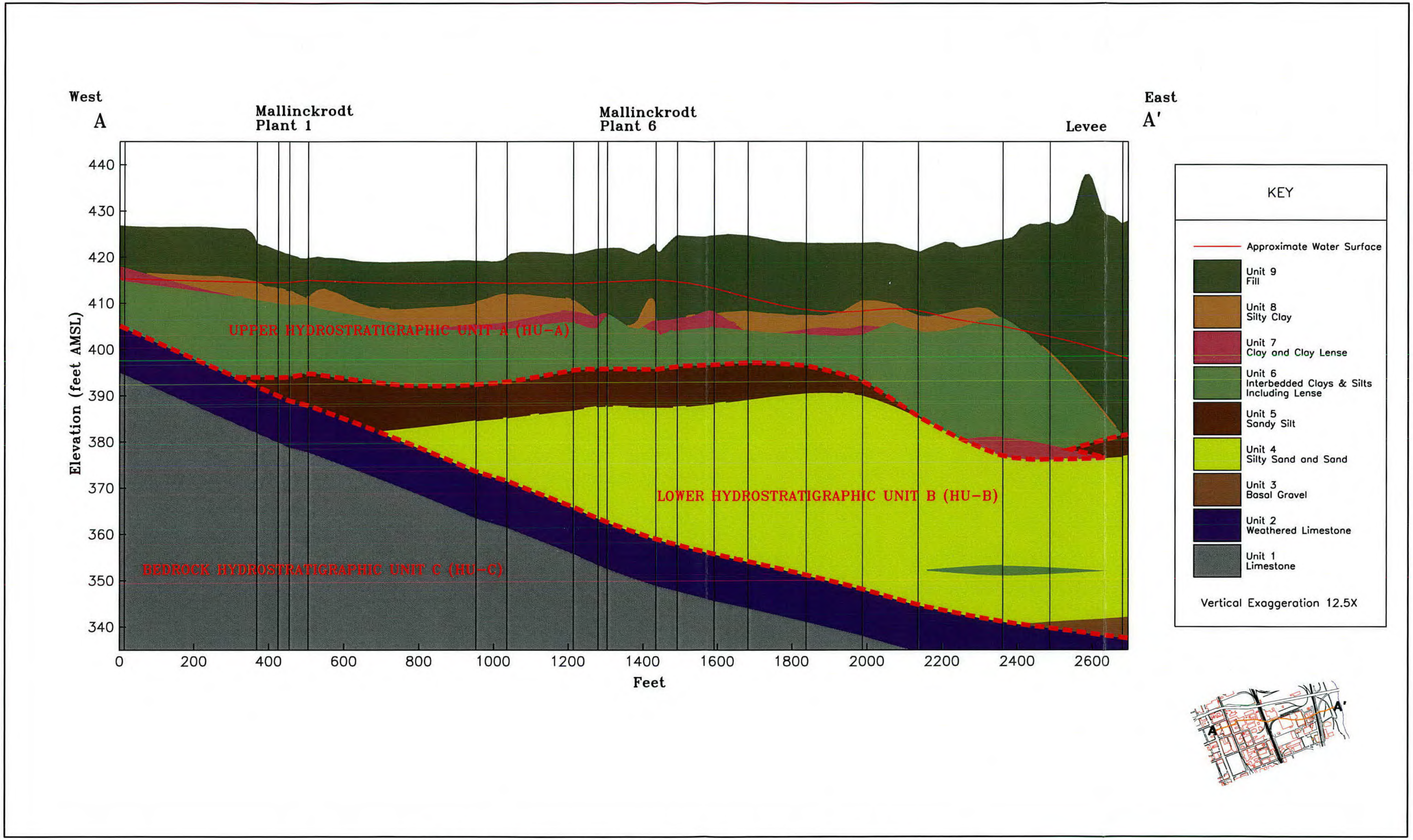

Figure 1–5. Hydrostratigraphic Cross–Section of the St. Louis Downtown Site Area

1.4.1.4 Radiological and Chemical Characterization Summary

The following information, as compiled from the SLDS Record of Decision (ROD) [USACE, 1998b], provides a summary of the characterization studies performed to identify the extents of impacts from materials used in MED/AEC processes. As a result of characterization of the soil, ground water, surface water, sediment, air, and structures associated with SLDS, radiological contamination attributable to MED/AEC operations at Mallinckrodt was determined to be present in the surface and subsurface. The principal risk concern is potential exposure to radiological constituents which include the thorium, actinium, and uranium decay series that are attributable to MED/AEC operations at the site. The metals arsenic, cadmium, and total uranium were also identified for cleanup.

A RI was conducted in accordance with CERCLA to determine the nature and extent of contamination at SLDS relevant to this operable unit (DOE, 1994a). Analytical results for radiological and chemical characterization surveys are summarized in the RI report and the RI Addendum (DOE, 1994a; DOE, 1995).

Soil characterization results indicated that the areas associated with MED/AEC activities were principally contaminated with radionuclides, including radium-226 (Ra-226), Ra-228, thorium-230 (Th-230), Th-232, uranium-234 (U-234), U-235, and U-238, and associated daughter products (USACE, 1998b). Radiological constituents have also been identified on vicinity properties with the highest levels occurring at the City Property. The extent of contamination is limited mostly to shallow soils; however, contaminants may have migrated to depths of about 7 m (20 ft) below ground surface at Plants 2 and 6. Metals and volatile organic compounds (VOCs) have also been detected across the site but generally occur in limited pockets (USACE, 1998b). The ROD for SLDS identified arsenic (As) and cadmium (Cd) as contaminants of concern (COCs) in addition to the radionuclides indicated above.

Sediment samples were collected as part of the RI from 50 manholes and 23 storm drains or process pipelines as part of the initial RI completed in 1994. These samples indicated U-238, Ra-226, Th-232, and Th-230 contamination exceeding guidelines in 36 manholes and within 7 pipelines (DOE, 1995). Sampling of Mississippi River sediments along City of St. Louis property in 1987 and 1988 indicated Th-230 and Ra-226 contamination ranging from 1 to 160 picocuries per gram (pCi/g) and 6 to 1,100 pCi/g, respectively. Subsequent confirmatory sampling conducted in 1992 indicated no levels of radioactivity above minimum detectable activities (MDAs). Higher flows between the sampling events are suspected to have flushed the constituents downstream.

Ground water at the SLDS has been impacted by historical operations related to MED/AEC activities and other site industrial uses. Radiological contamination is limited to the HU-A through sorption processes and is dominated by uranium activity. Other isotopes have historically been close to background levels. Ground-water monitoring wells in the vicinity of the former Building K1E have historically had consistently elevated levels of uranium activity in excess of background levels. VOCs detected in the HU-A include benzene, 1,2-dichloroethene (DCE), trichlorethylene (TCE), and vinyl chloride. Inorganic contaminants detected at significant concentrations in the HU-A include As, Cd, iron (Fe), manganese (Mn), chloride (Cl_2), and sulfate (SO_4).

Radiological COCs, as identified by the ROD [Actinium-227 (Ac-227), Protactinium-231 (Pa-231), Ra-226, Th-230, Th-232, and U-238], have not been found in the HU-B at concentrations exceeding their respective maximum contaminant levels (MCLs). In general, historical concentrations of these isotopes in the HU-B have been near background levels (DOE, 1995).

Non-radiological COCs as identified by the ROD (As, Cd, and total uranium) have not been found in the HU-B at levels of significance. Organic contaminants, not selected as COCs in the ROD, have been detected in the HU-B at significant levels including 1,2 DCE, vinyl chloride, methylene chloride, TCE and hexachlorobenzene. The primary inorganic contaminants found in the HU-B that are attributed to non MED/AEC sources, and are not COCs under the ROD, are barium (Ba), Fe, Mn, and Cl_2.

1.4.2 SLAPS and CPs

SLAPS is an 8.8-ha (21.7-acre) site located approximately 18 km (11 mi) northwest of SLDS (Figure 1-2). SLAPS and the Lambert-St. Louis Airport are owned by the City of St. Louis Airport Authority, but are located in unincorporated St. Louis County. SLAPS is immediately north of the Lambert-St. Louis International Airport and is bordered by McDonnell Boulevard and open recreational areas (ballfields) to the north and east, and Coldwater Creek to the west (Figure 1-6).

Several CPs beyond SLAPS have been included in previous investigations. CPs include the ballfields located immediately north of SLAPS across McDonnell Boulevard; Coldwater Creek and the original flood plain located along the northern side of the creek; a portion of the airport property and Banshee Road located just south of the railroad and SLAPS; The Norfolk and Western Railroad which runs along the southern boundary of SLAPS; McDonnell Boulevard which runs along the northern boundary of SLAPS; and a portion of the Boeing parking lot located across Coldwater Creek to the west of SLAPS. The CPs were investigated due to known or suspected contaminant migration routes. These routes include wind deposition, surface drainage and overland flow, flooding, ground-water movement, and former routes of waste transportation.

1.4.2.1 Operational History

Between 1946 and 1966, SLAPS was used to store MED/AEC residue material generated by uranium separation processes at Mallinckrodt Chemical Works. MED acquired SLAPS in 1946, and used the site to store uranium-bearing residues from SLDS from 1946 until 1966. In 1966, Continental Mining and Milling Company of Chicago purchased these residues. By 1967, the stored residues had been moved by Continental Mining and Milling from SLAPS to another site located at 9200 Latty Avenue in Hazelwood, Missouri, for subsequent shipment to Canon City, Colorado. Some barium sulfate material remaining at 9200 Latty Avenue was taken to a landfill in western St. Louis County. After most of the residuals had been removed from SLAPS, site structures were demolished and buried on the property along with approximately 60 truckloads of scrap metal and a vehicle that had become contaminated (EPA, 1989). Clean fill material was spread over the disposal area from 0.3 to 1 m (1 to 3 ft) to achieve surface radioactivity levels acceptable at that time.

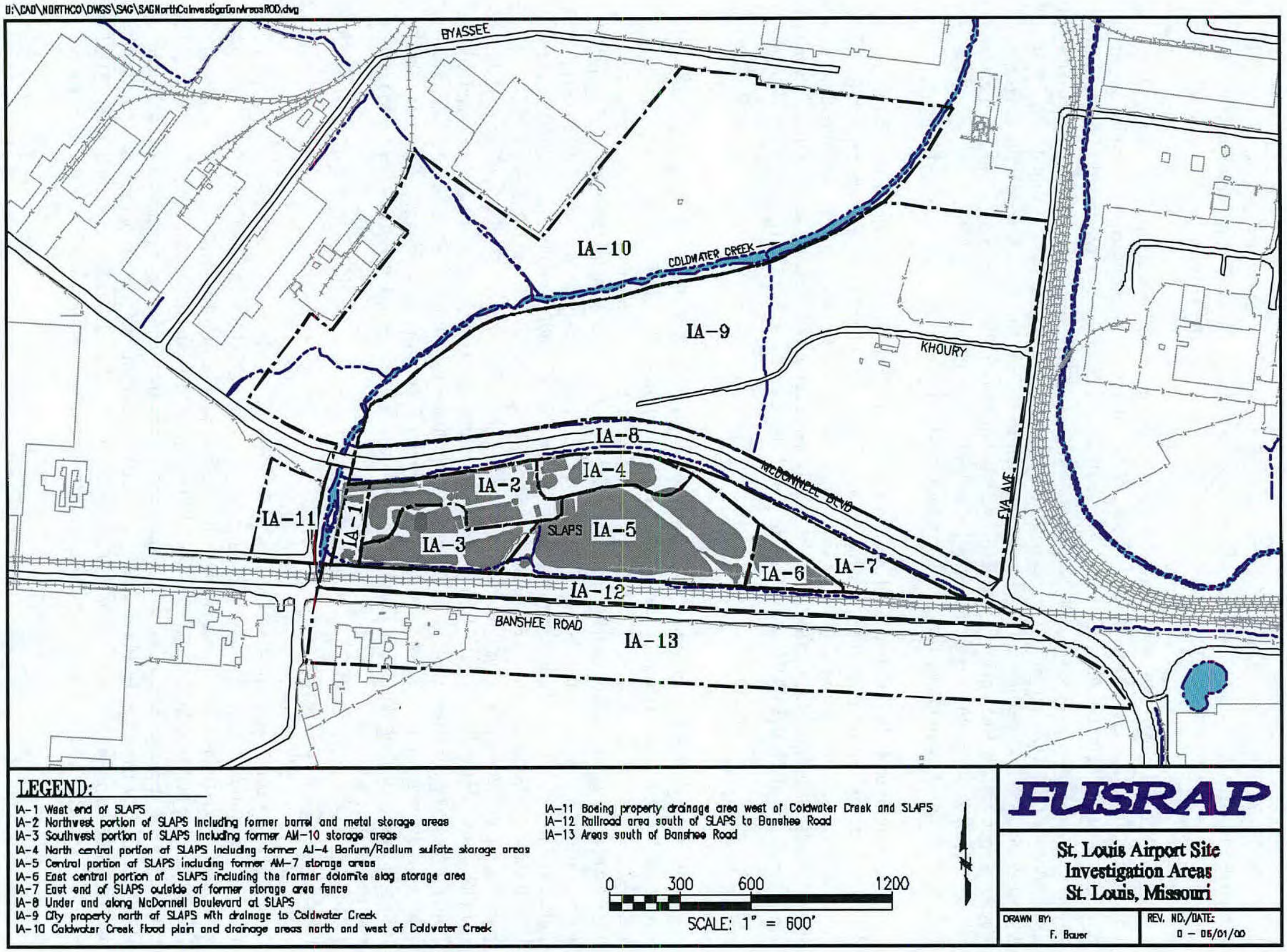

Figure 1-6. Plan View of the St. Louis Airport and Contiguous Properties

In 1973, the United States Government and the City of St. Louis agreed to transfer ownership of SLAPS by quitclaim deed from AEC to the City of St. Louis Airport Authority. The City of St. Louis Airport Authority remains the owner of the property.

The 1985 Energy and Water Development Appropriations authorized DOE to reacquire the property for use as a permanent disposal site. VPs that have been included in characterization activities to date include Coldwater Creek, the ball fields, Norfolk and Western Railroad, and Banshee Road to the south, and former transportation routes between the HISS and SLAPS (Latty Avenue, McDonnell Road, Pershall Road, Hazelwood Avenue, Eva Avenue, and Frost Avenue). SLAPS and vicinity is currently zoned light industrial; the nearest residential areas are located about 800 m (0.5 mi.) to the west. Additional information on land use in the area is presented in the Remedial Investigation Report for the St. Louis Site (DOE, 1994a) and the Feasibility Study/Environmental Impact Statement for the St. Louis Site (DOE, 1994b).

On October 4, 1989, SLAPS, HISS and certain VPs were listed on the NPL. The initial RI, completed by the DOE in 1994, addressed SLAPS and provided limited characterization of radioisotope contamination in Coldwater Creek and chemical and radiological contamination in the ballfields. Engineering Evaluation/Cost Analyses (EE/CAs) for two interim actions have been completed under the CERCLA at the site (DOE, 1997a; USACE, 1998d).

1.4.2.2 Waste Inventory

Waste materials that were historically stored at SLAPS included residue material generated by uranium separation processes at Mallinckrodt Chemical Works. The residue material included ore raffinate, which was stored on the ground, and radium-bearing residues, which were stored in drums. Barium cake residue was also stored on the ground at the site. Formal waste inventory records at SLAPS do not exist. Based on records of materials transferred to HISS in 1966, an estimated 9,072 metric tons (10,000 tons) of Colorado raffinate; 36,470 metric tons (40,200 tons) of leached barium sulfate cake; and 12 metric tons (13 tons) of uranium were historically stored at the site. Other materials stored or disposed at the site included used dolomite liner and recycled magnesium fluoride liner, tailings produced by uranium recovery from magnesium fluoride slag, 50,000 empty drums, 3,175 metric tons (3,500 tons) of radioactively contaminated scrap metal, and 2,400 drums containing uranium-bearing sand and miscellaneous radioactive scrap and residues. Some of these materials were buried in pits dug on the site.

1.4.2.3 Site Characteristics

The general topography of the region consists of gently rolling uplands dissected by broad, steep-walled river valleys up to 16 km (10 mi.) wide. SLAPS covers 8.9 ha (22 acres) and is situated on an upland area between the Missouri and Mississippi River floodplains (Figure 1-2). The 100-year floodplain at SLAPS is 159 m (522 ft) amsl (FEMA, 1983). The local topography of the site is flat due to historical construction and grading activities, with an elevation ranging from 155 to 162 m (510 to 530 ft) amsl from east to west across the site. The ball fields cover approximately 32 ha (80 acres) of an abandoned former recreation area. The northern part of this area was constructed on former lowlands, which were filled with various materials.

The site is located within the Oak-Hickory-Bluestem Parkland Section of the Prairie Parkland Province. Prior to industrial development, deciduous woodlands interspersed with open prairie characterized the site. Because of extensive site activities, the native soil column has been largely disturbed or covered. Surface drainage from the site was directed through four drainage ditches that ultimately discharged to Coldwater Creek.

Coldwater Creek is the principal surface water feature in the site vicinity. This stream is a Class C waterway (periodic no flow conditions) designated for livestock and aquatic life use. The creek originates south of SLAPS, has a channel length of 31 km (19.5 mi.), and a drainage basin of 122 square kilometer (km^2) [47 square miles (mi^2)]. Water quality in the creek has been impacted by industrial discharges from multiple facilities including storm-water runoff and discharges from three sewage treatment facilities.

The geology of the St. Louis area was briefly summarized in Section 1.4.1.3. The generalized stratigraphic column for the SLAPS is shown on Figure 1-7 In the vicinity of SLAPS, surficial deposits (Unit 1) include topsoil, meander fill, and anthropogenic fill (rubble, scrap metal, gravel, glass, slag, and concrete) generally less than 4 m (14 ft) thick. Pleistocene loess and glacial lacustrine deposits underlie the fill (Units 2, 3, and 4). Unit 2 corresponds to wind-deposited loess and has a thickness of 3 to 9 m (11 to 30 ft). Unit 3, which is subdivided into subunits 3T, 3M, and 3B, consists primarily of clay and silt lakebed deposits. Each of these clay subunits has a thickness of up to approximately 9 m (30 ft). Unit 4 consists of clayey gravel with increasing fine- to very-fine sand and sandy gravel near the bedrock contact. Below the soil deposits are Units 5 and 6, which comprise of shale/siltstone and limestone, respectively. Depth to bedrock ranges from about 17 m (55 ft) on the east of SLAPS to a maximum of 27 m (90 ft) towards Coldwater Creek.

Figure 1-8 illustrates the conceptual hydrostratigraphic model for SLAPS. Five hydrostratigraphic zones (HZ) are recognized beneath SLAPS. The fill (Unit 1) and the Pleistocene, glacially-related sediments of stratigraphic Unit 2 and subunit 3T comprise the HZ-A. Clay with low vertical permeability comprising subunit 3M of stratigraphic Unit 3 is HZ-B. HZ-C is comprised of the stratigraphic subunit 3B and Unit 4. The shale and limestone are recognized as HZ-D and HZ-E, respectively. Precipitation and shallow ground-water flow in HZ-A is toward Coldwater Creek under normal flow conditions. Although data is not available for high water conditions, it is likely that ground-water flow directions near the creek are temporarily reversed at these times. HZ-B acts as an aquitard across the entire SLAPS and HISS area. The ground-water characterization report for SLAPS (USACE, 1998c) concluded that hydraulic communication did not exist between the HZ-C and Coldwater Creek. Average depths to the shallow water surface at the site range from near the ground surface during the winter months to about 3 m (10 ft) during the summer months.

Site characterization activities at SLAPS have documented the radiological and chemical impacts to soils, ground water, surface water, and stream sediments (DOE, 1994a; DOE, 1995). The primary radionuclides of concern in surface and subsurface soils include Ra-226, Th-230, and U-238. Other radionuclides of interest in surface and subsurface soils include daughter decay products Pa-231 and Ac-227. Although these primary radionuclides were detected in site ground water, they were not present above their respective benchmarks. Only total uranium continues to be the primary ground-water radionuclide above its MCL (USACE, 1998c).

1.4.3 HISS and Latty Avenue VPs

HISS is located approximately 1.6 km (1 mi.) north of the St. Louis Airport at 9200 Latty Avenue (Figure 1-2). This 3.2-ha (8-acre) site is near various industrial properties and is bounded to the north by Latty Avenue, to the east by Stone Container Company, to the south by an undeveloped lots, and to the west by Futura Industries. Multiple rail lines owned by the Norfolk and Western Railroad lie to the west and south of the site. Two large piles of covered contaminated soil occupy the central portion of HISS. The site is surrounded by security fencing. Coldwater Creek is located about 122 m (400 ft) west of the site. SLAPS is located approximately 1.2 km (0.75 mi.) to the south of HISS (Figure 1-9).

1.4.3.1 Operational History

HISS was used beginning in 1966 and 1967 for the staging and storage of residues transported from SLAPS after purchase by Continental Mining and Milling Company (see Section 1.4.2). In 1977, the site was purchased by Futura Coatings who prepared the property for use by demolishing some of the structures and cleared a 1.4-ha (3.5-acre) tract of land for new infrastructure. Since 1977, the site has been used for the storage of radioactively contaminated soil and debris, as well as Futura operations.

1.4.3.2 Waste Inventory

The waste materials that were historically stored at HISS included uranium extraction and refining residues. These materials included an estimated 96,161 metric tons (106,000 tons) of Congo pitchblende and Colorado raffinate; 36,469 metric tons (40,200 tons) of barium sulfate cake; and 317 metric tons (350 tons) of miscellaneous process residues and wastes (DOE, 1990a). Soils and debris generated by Futura Industries in 1979 were placed on the eastern half of the property to form the main storage pile of 9,939 cubic meters (m^3) [13,000 cubic yards (yd^3)]. Another 10,704 m^3 (14,000 yd^3) of contaminated soils were added to this pile by additional remedial action along Latty Avenue during 1984 (DOE, 1990a). A supplemental storage pile 2,500 m^3 (3,270 yd^3) was created in 1986 to store radioactively contaminated soil from an off-site drainage improvement project in the city of Berkeley. Two piles, containing approximately 6,116 m^3 (8,000 yd^3) of soil and debris were located on the Stone Container Site to store roofing and siding debris, asphalt, rubble, and soils derived from off-site construction activities. These piles were removed by June 2000.

1.4.3.3 Site Characteristics

Sections 1.4.1 and 1.4.2 contain a summary of the topographic, geologic, and physiographic setting for the St. Louis area and the area encompassing SLAPS and HISS. HISS is nearly level and lies at an elevation between about 157 and 159 m (514 and 522 ft) amsl, except for the storage piles, which reach heights of up to 4 m (12 ft) above grade. Surface runoff from the site is directed through drainage ditches. Drainage ditches around the main storage pile drain to the south toward to an intermittent tributary to Coldwater Creek. Drainage ditches around the secondary storage pile drain to the north, ultimately feeding a tributary to Coldwater Creek. The drainage conveyances around the piles are monitored via National Pollutant Discharge Elimination System (NPDES) storm water discharge permits.

Zone	Period	Epoch	Stratigraphic	Thickness (ft.)	Description
Hydrostratigraphic zone (HZ)-A	Quaternary	Holocene	FILL/TOPSOIL	0-14	**Unit 1** Fill - Sand, silt, clay, concrete, rubble. Topsoil - Organic silts, clayey silts, wood, fine sand.
		Pleistocene	LOESS (CLAYEY SILT)	11-32	**Unit 2** Clayey silts, fine sands, commonly mottled with iron oxide staining. Scattered roots and organic material, and a few fossils.
			GLACIO-LACUSTRINE SERIES: SILTY CLAY	19-75 (3) 9-27 (3T)	**UNIT 3** Silty clay with scattered organic blebs and peat stringers. Moderate plasticity. Moist to saturated. (3T)
Hydrostratigraphic zone (HZ)-B			VARVED CLAY	0-8	Alternating layers of dark and light clay as much as 1/16 inch thick (3M)
			CLAY	0-26	Dense, stiff, moist, highly plastic clay. (3M)
Hydrostratigraphic zone (HZ)-C			SILTY CLAY	0-20	Similar to upper silty clay. Probable unconformable contact with highly plastic clay. (3B)
			BASAL CLAYEY & SANDY GRAVEL	0-6	**UNIT 4** Glacial clayey gravels, sands, and sandy gravels. Mostly chert.
Hydrostratigraphic zone (HZ)-D	Pennsylvanian		Cherokee (?) group (undifferentiated)	0-35	**UNIT 5** BEDROCK: Interbedded silty clay/shale, lignite/coal, sandstone, and siltstone. Erosionally truncated by glaciolacustrine sequences. (Absent at HISS).
Hydrostratigraphic zone (HZ)-E	Mississippian		STE GENEVIEVE ST. LOUIS LIMESTONES	100+	**UNIT 6** BEDROCK: Hard, white to olive, well cemented, sandy limestone with interbedded shale laminations.

Figure 2-17 Generalized Hydrostratigraphic Column for SLAPS and HISS

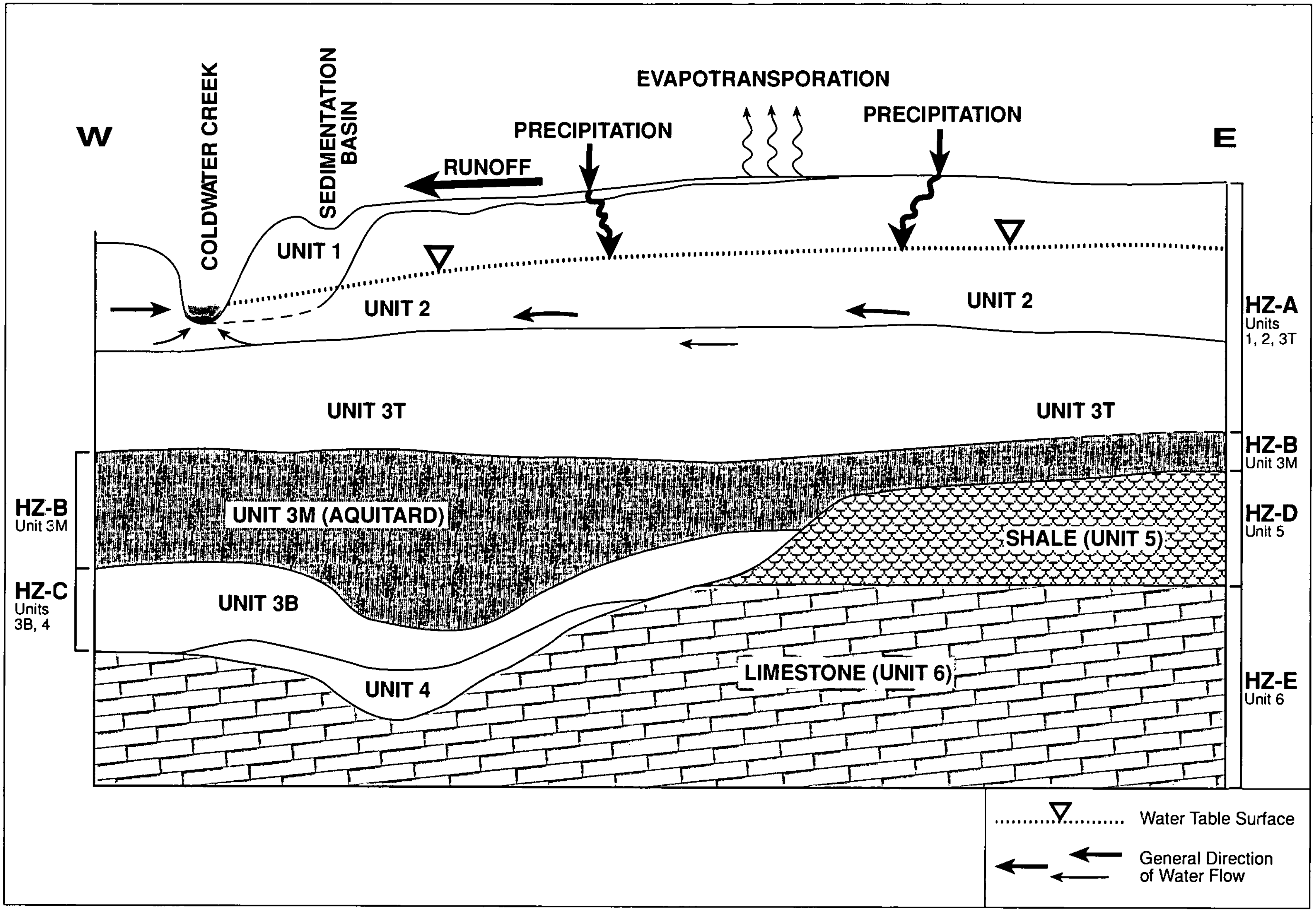

Figure 1-8. Conceptual Hydrogeologic Model for SLAPS

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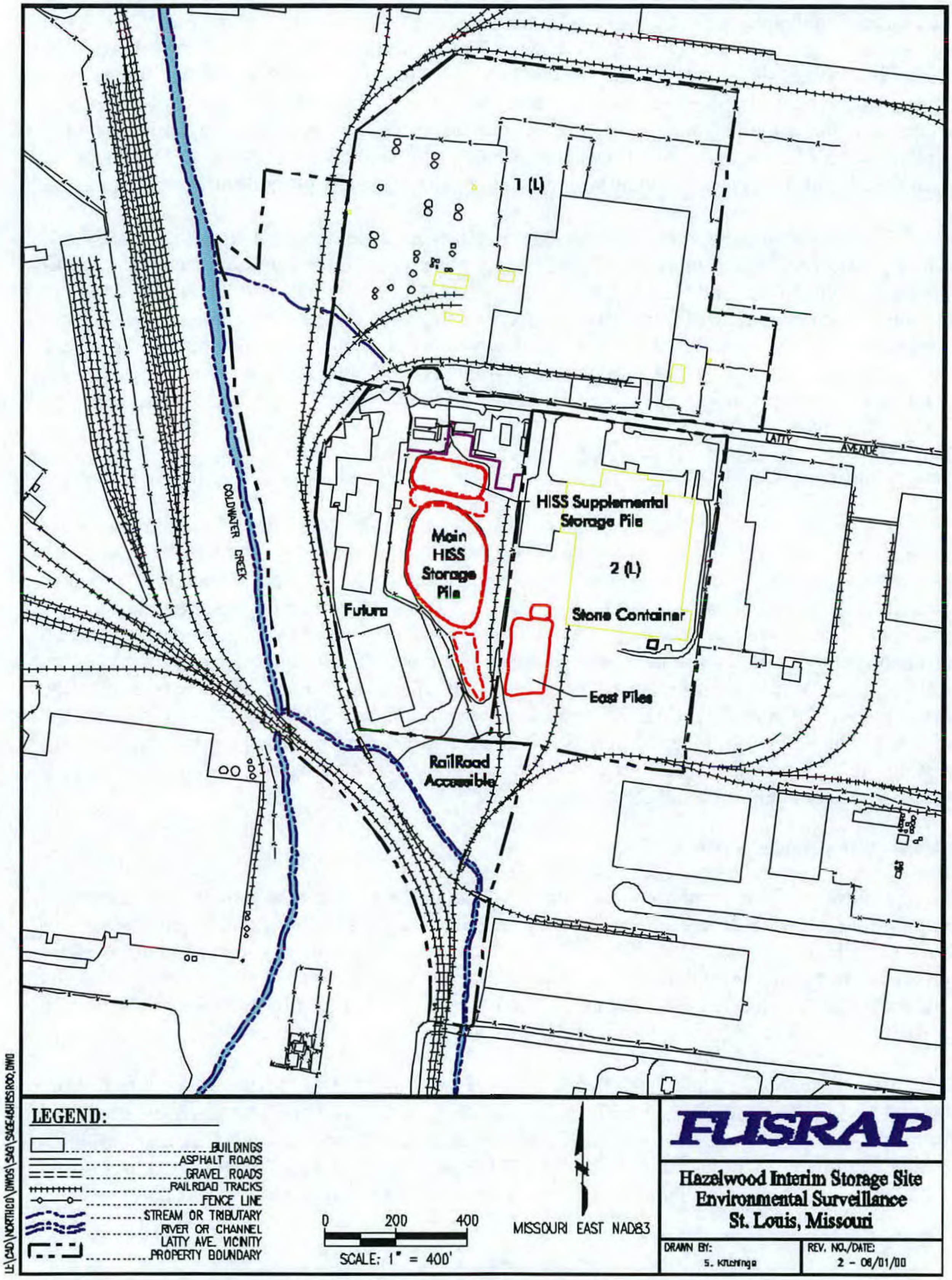


Figure 1-9. Plan View of HISS and Latty Avenue Vicinity Properties

The geology of the St. Louis area is briefly summarized in Section 1.4.1.3. The generalized stratigraphy beneath HISS was presented with that of SLAPS on Figure 1-7. The hydrogeologic and geologic setting at the HISS is similar to that at SLAPS, with two exceptions. The Pennsylvanian shale bedrock unit present at SLAPS is absent at HISS. In addition, HZ-B is present throughout HISS. The potentiometric surface at the site indicates a ground-water high located near the center of the site with radial ground-water flow patterns away from the high point. Coldwater creek is the baseflow discharge point for shallow ground water. Depths to the ground-water surface typically range from 1 to 2 m (4 to 6 ft) below ground surface (bgs).

Site characterization activities to date at HISS have documented impacts to soils and ground water. The storage piles at HISS and Latty VP 2 contain the same radionuclide suite as identified at the SLDS and SLAPS (Ra-226, Th-230, Th-232, U-238 and associated daughter products). The occurrence of non-radiological contaminants is limited to barium, total petroleum hydrocarbons, benzene, and PAHs in the small Latty VP2 soil pile. Both surface and subsurface soils to depths of 2 m (6 ft) at HISS are contaminated with the signature radionuclide suite. Radiological constituents have also been identified on the VPs primarily at depths less than 1 m (3 ft) (DOE, 1994a; DOE, 1995).

1.4.4 Coldwater Creek

Coldwater Creek is the principal surface water feature in the North County vicinity, including the areas of SLAPS, HISS and their VPs. This stream is a Class "C" waterway (periodic no flow conditions) designated for livestock and aquatic life use. The creek originates south of SLAPS, has a channel length of 31 km (19.5 mi.), and a drainage basin of 122 km^2 (47 mi^2). Coldwater Creek continues for 24 km (15 mi.) in a northeasterly direction through Hazelwood, Florissant, and unincorporated areas of the county. It continues to flow along the northern edge of the unincorporated community of Black Jack until it discharges into the Missouri River (Figure 1-2). Coldwater Creek flows for approximately 152 m (500 ft) along the western border of SLAPS (see Figure 1-6). Coldwater Creek also serves as a discharge point for existing NPDES permits at SLAPS and HISS and future monitoring of these discharges may require additional monitoring of the creek.

1.4.4.1 Site Characteristics

Coldwater Creek, with the exception of 1.9 km (1.2 mi.) under the airport, is accessible to the public. Coldwater Creek is classified by MDNR as a Class “C” waterway downstream of SLAPS. Class “C” waters are streams that may cease flow in dry periods but maintain permanent pools that support aquatic life. Flooding in Coldwater Creek occurs annually. Coldwater Creek, projected downstream of SLAPS from US Route 67 to its mouth, is designated for livestock/wildlife watering and aquatic life usage.

Water quality in Coldwater Creek is generally poor due to surface water runoff from adjacent industrial properties. Water quality in the creek has been impacted by industrial discharges from multiple facilities including storm-water runoff and discharges from three sewage treatment facilities, and Lambert-St. Louis Airport. Ground-water discharge from SLAPS may occur by seepage into Coldwater Creek during normal and low creek stages.

1.5 Current Site Status

The FFA for the St. Louis Sites governs activities conducted under CERCLA (DOE, 1990a). The FFA, originally prepared by DOE, was adopted by USACE in its entirety at the time of transfer of the FUSRAP. Although the FFA addresses all St. Louis FUSRAP Sites, only SLAPS and HISS are listed on the NPL. Various interim and final actions have been conducted or are anticipated at the St. Louis Sites. In October 1998, the final ROD for accessible soils, and accessible sediments in storm sewers and drains, was issued (USACE, 1998b), which dictates the removal and off-site disposal of contaminated soil and on-site perimeter monitoring of ground water in the Mississippi River alluvial aquifer (HU-B). Ownership issues, agreements with stakeholders, and other regulatory requirements also affect the status of the sites.

In preparing each site-specific WD, a more detailed "current" characterization status should be provided, including applicable historical and recent activities, which have impacted site and/or support the sampling objectives and planned activities. References to reports and environmental documentation should be provided in support of each status summary. Use of preliminary (unvalidated) data is not appropriate when describing the current status.

1.6 Sampling Objectives

A primary objective of the SAG is to integrate protocols and methodologies identified under various USACE and regulatory guidance, which is intended for the SLS. Integration allows comparability of data among the sites based on common standards from interrelated media. Such integration allows standardized data management, validation, and reporting, which results in higher quality integration and interpretation of information across the program. Cost and time efficiencies are also realized by referencing pre-approved and accepted methodologies. By using common guidance and procedures, work plan preparation materials and attachments will be simplified, and its approval eliminated, thereby helping to reduce overall cost.

Sampling requirements for the SLS may evolve as a result of promulgation of new regulations, and standards. Accordingly, the SAG is designed to provide flexibility to meet these changes while ensuring that baseline standards are maintained. In order to provide this flexibility, the SAG was developed as a primary component within an integrated strategy for the SLS. This integrated strategy defines basic programmatic requirements that guide sampling procedures, sample management techniques and documentation, field QA/QC, analytic protocols, and laboratory QA/QC through this upper tier document. The structure for identified sampling/monitoring is delineated through programmatic documents such as the Environmental Monitoring Guide (EMG) [USACE, 1999b], which is an upper tier companion document to the SAG. Flexibility to address non-periodic environmental sampling, such as boundary delineation for remedial design, verification sampling, or in-situ waste characterization is provided for in this integrated strategy by issuance of a WD and/or Final Status Surveys. Environmental monitoring data obtained through these upper and lower tier plans are typically reported to the U.S. Environmental Protection Agency (USEPA) Region VII quarterly as required by the FFA.

The following sections define objectives of some additional site data, which may be needed for various sampling requirements at the SLS. Other objectives may be appropriate for a particular sampling activity. If another objective, not listed here is used, it should be defined and supported in the WD.

1.6.1 Data to Support Characterization Studies

Initial data may be required to characterize the nature and extent of contamination. Data may also be required to characterize the soil, geological, and hydrogeological setting of the sites that affect the migration of contamination within and beyond the sites. Base maps should reference the Missouri State Plane Coordinate System. Several stages of data collection may be required to adequately characterize the types and concentrations of contamination as well as the areal extent and depth of contamination. Data are also acquired on the chemical characteristics of the contaminants in order to develop baseline risk assessments. Background reference areas should also be identified, and appropriate benchmarks defined.

1.6.2 Data to Support Feasibility Studies

Data required for feasibility studies may include the characterization of data as well as additional data necessary to evaluate the alternatives for remedial action at the sites. Data are required on land use plans as well as the types of remedial technologies being screened for remedial action at the sites. Sufficient data on the site and contaminants as well as the remedial technologies must be obtained in order to adequately evaluate feasible remediation actions and provide estimated costs.

1.6.3 Data to Support Remedial Design/Removal Actions

Data are required to support the remedial design and removal activities in order to define pre-excavation contaminant boundaries and assist in verifying remediation actions. Data collected to support the remedial activities and pre-excavation boundary delineation should focus on soil benchmarks and geotechnical properties. The approach to determining the extent of impact is to divide the site into investigative areas (IAs), based on known former uses and depositional mechanisms, and to methodically determine the constituents present and the impact boundaries within accessible areas. Spatial variability of the soil contaminants should be evaluated to further define excavation limits prior to removal activities. Analytical results should be used to minimize the volume of soil requiring off-site disposal. The results may also be used for processing of wastes for off-site disposal and confirming the absence or presence of characteristically hazardous constituents. An on-site laboratory using analytical quality instruments (gamma spectrometry for radionuclides) will be utilized to rapidly identify the location(s) of the boundaries of radionuclide-impacted areas. Ground-water and surface-water quality data may be acquired to monitor impacts of remedial action.

1.6.4 Data to Support Environmental Monitoring/Permits

Environmental monitoring will continue to be required at designated St. Louis Sites for residual contaminants left in place where remedial measures have been completed in accordance with remedial objectives. Principal monitoring requirements are anticipated to be associated with air, ground water, and surface water. The need to obtain certain permits and documentation for remedial actions may require monitoring of other media such as storm-water runoff. Data requirements for permits include meteorological data in addition to analytical data of the media being monitored. The frequency and type of data necessary to satisfy environmental monitoring requirements at the St. Louis FUSRAP Sites are identified in the EMG (SAIC, 1999). Specific objectives and monitoring requirements for each fiscal year of the USACE will be defined in the annual Environmental Monitoring Implementation (EMIs).

1.6.5 Health and Safety Data

Occupational Safety and Health Administration (OSHA) and USACE requirements necessitate the collection of appropriate data to ensure worker safety. Data provided by the original site investigations are sufficient to indicate the need to minimize dermal contact with impacted soils and water at the sites. Airborne particulates could also present a threat by inhalation or ingestion. Site-wide ambient air quality monitoring may be performed as deemed necessary. Breathing zone air monitoring is also anticipated during field sampling investigations. Revisions to personal protective equipment (PPE) requirements will be made based on the data as they are collected. Details of the decision criteria and methodology for changing working requirements are to be provided in Section 6.0 of the Site Safety and Health Plan (SSHP). Screening tools (e.g., gamma surveys) may be used to roughly locate areas impacted by a contaminant.

1.6.6 Background Reference Area Sampling

Background data are necessary to provide a reference for specific survey units or investigative areas at the St. Louis FUSRAP Sites. Using available historical and characterization data collected, background reference areas should be identified in non-impacted areas. If supplemental background data are needed, procedures, frequency, and types of samples in the background reference area should be identified using guidance in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) or other applicable guidance. Several background reference areas may be necessary to encompass all of the environmental media. Using the guidance in MARSSIM, background areas should also be characterized with a sufficient number of data points to statistically support references to background concentrations.

1.6.7 Final Status Survey

Data collected for site-specific final status surveys are used to confirm that the contamination or level of radioactivity within the survey unit or investigative area has been removed or mitigated to satisfy protective action levels. These levels are typically defined in MARSSIM as derived concentration guideline levels (DCGLs). The final status survey will demonstrate compliance with the DCGLs and, therefore, requires accurate data to confirm compliance. The final status survey should incorporate the steps defined in MARSSIM to guide the acquisition of data to demonstrate compliance. These steps include, at a minimum, the following:

- Classify the survey units;
- Specify the decision area;
- Determine the DCGLs;
- Calculate the relative shift;
- Determine and obtain the number of samples per survey unit;
- Estimate the sample grid spacing;
- Perform evaluations for small areas with elevated radioactivity; and
- Determine if the number of samples is reasonable.

A ROD will define the approach and cleanup levels for all contaminants including radiological and chemical constituents.

1.7 Development of an Adequate Data Set

Systematic evaluation of the objectives of the investigation, the use of the data to be collected, and an evaluation of the data quality requirements form a methodology for designing an adequate and appropriate sampling plan (or WD). The following discussion presents three approaches to defining the sampling requirements: the Observational Approach, which focuses on the data needed to define and evaluate site conditions based on a source/pathway/receptor evaluation; Adaptive Sampling and Analysis, which incorporates field analytical methods and on-site decision-making; and the EPA's DQO process (EPA 1987; EPA 1993a; EPA, 1994d), which focuses on a need/decision/action evaluation for the site. Any of these planning methodologies may be used to define the minimum acceptable and necessary data set for each investigative area or media type.

This section provides guidance for developing site-specific DQOs. The justification for these DQOs should be supported in the WD. Once the minimum data set is defined, refinements and additions arc made to fulfill all identified and anticipated data requirements and to resolve or constrain uncertainty. These approaches require systematic identification of the end use of the data. If there is no identifiable action to be taken or decision to be made based on a given proposed data set, then these data may be deleted from the sampling plan. The systematic evaluation of collected data and the decision/action process result in collecting only needed data in a cost-effective and expedited manner.

1.7.1 Observational Approach

The Observational Approach assesses the site's "probable conditions" based on the available data. It is intended that the "probable conditions" be understood to the extent necessary to meet the sampling objectives; i.e., evaluate potential risks and resolve data gaps.

As part of the approach, a detailed conceptual model is developed based on the current understanding of site physical and contaminant conditions including:

1. Primary sources;
2. Primary release mechanisms;
3. Secondary sources;
4. Secondary release mechanisms;
5. Pathway of migration;
6. Exposure routes; and
7. Potential receptors.

The primary release mechanisms include (but may not be limited to):

1. Erosion;
2. Wind-blown dust;
3. Surface water runoff;

4. Operation activities/construction disturbances;
5. Infiltration/percolation to adjacent and underlying soils;
6. Solubility or suspension in ground water; and
7. Ground-water infiltration/discharge to surface water.

Secondary release mechanisms may include surface water and features receiving surface water such as drainageways and sediments, ground water, soils surrounding and underlying storage and disposal areas, and on-site and off-site sediments. Secondary sources may also include receptors, which consume contaminated biotic or abiotic matrices.

Secondary release mechanisms include (but may not be limited to):

1. Channel flow/surface water transport;
2. Sediment deposition (in-channel and over-bank);
3. Sediment traps;
4. Dredging of sediments from drainageways;
5. Overland flow/storm-water runoff;
6. Infiltration to subsurface soil;
7. Fugitive dust; and
8. Potential ground-water movement from source areas.

Exposure routes for human and ecological receptors include:

1. Inhalation of dust;
2. Ingestion of soil, surface water, ground water, contaminated fish, plants, or animals;
3. External exposure; and
4. Dermal contact with soil, surface waters, sediments, or ground water.

The Observational Approach uses "decision rules" (as does the DQO process) for the purpose of linking data needs and uses. This approach helps to focus the sampling plan and sampling strategies by developing a conceptual model that identifies sources, pathways, and potential receptors. To augment the conceptual model, a DQO discussion that follows EPA's guidance is presented in Section 1.7.3.

1.7.2 Adaptive Sampling and Analysis

Adaptive Sampling and Analysis is an approach that has been successfully used at a number of Department of Defense (DOD) facilities (Robbart and Johnson, 1996; EPA, 1995). This approach allows the use of field (as well as off-site) analytical methods, which can produce data quickly and allow on-site decision-making to determine the need to collect additional data. This approach requires analytical techniques that produce prompt turnaround results, adequate data quality, and detection limits that meet the project objectives. The adaptive sampling approach also requires a means for rapidly making decisions in the field regarding the course of the sampling program. This is accomplished by on-site computer processing using geostatistical, visualization, and other data analysis software (e.g., Earth Vision) and the use of an on-site laboratory and technical decision team.

1.7.3 Data Quality Objectives Process

As previously stated, the EPA DQO process (EPA, 1987; EPA, 1993a; EPA, 1994d) was used in conjunction with the Observational Approach and Adaptive Sampling and Analysis to develop this SAG. The seven steps that comprise the DQO process are as follows:

Step 1: State the problem.
Step 2: Identify the decision.
Step 3: Identify inputs to the decision.
Step 4: Define the study boundaries.
Step 5: Develop a decision rule.
Step 6: Specify limits on decision errors.
Step 7: Optimize the design for obtaining data.

Step 1: State the Problem - The objective of this step in the DQO process is to develop a concise description of the problem, identify the primary organizations involved in the study, provide a list of the planning team members' qualifications, and identify the primary decision maker(s) for the study (EPA, 1994d). A project organization structure, including key USACE team members, is provided in the QAPP (Section 3.0).

Step 2: Identify the Decision - The goal of this step is to define the questions that the study will attempt to resolve and to identify the alternatives that may be taken based on the outcome of the study. The study questions and their corresponding alternatives will then be combined to form decision statements.

The following is a list of assumptions, which have been made in the process of developing the decision statements:

1. USACE is authorized to remediate COCs directly resulting from MED/AEC activities, along with any other constituents that may be mixed with the COCs.

2. Applicable environmental guidelines, such as those developed by DOE, the Nuclear Regulatory Commission (NRC), EPA, or MDNR will be used to identify benchmarks or remediation goals for soil, air, and water. Other federal/state environmental or risk-related benchmarks for non-radionuclides will be considered based on the residential and industrial criteria in soils, and MCLs or drinking water criteria in water.

3. Screening technologies will be used whenever possible to define the real extent of the contaminant, identify intervals for biased sampling, and define the presence and depth of fill areas. Various radiological screening methods may be used to define areas of radiological or chemical impact. These methods are assumed to correlate with laboratory data.

4. Sampling to ensure the safety of on-site remedial investigation workers will be addressed in the SSHP.

The goal of the SAG is to outline the methods to gather the data needed to meet the stated objectives. Specific study questions should be developed for each work task or sampling activity. The following is a list of principal or general study questions, which identify key unknown conditions or unresolved issues that may be investigated during all sampling activities:

1. Are worker safety and public access adequately controlled?
2. What is the distribution of uncertainty associated with impacted accessible soil at the site with radiological activity levels exceeding the current remedial guidelines?
3. Are non-radiological potential constituents of concern (PCOCs) present in soil exceeding Resource Conservation and Recovery Act (RCRA) hazardous criteria?
4. Are adequate background soil and ground water data available?

Decision statements are developed from the principal study questions. Decision statements are to be stated in the following manner: "Determine whether the unknown environmental conditions/issues/criteria from the Principal Study Questions require (or support) taking alternative actions" (EPA, 1994d). The decision statements generally apply to all SLS sampling activities:

1. Determine where the contaminants exceed benchmarks requiring remedial action.
2. Identify and develop a set of criteria to determine when adequate data have been collected to assess the volume and uncertainty limits for specific remedial removal actions based on adaptive sampling strategies.

These decisions may be made using the data collected and additional data referenced or collected under task- or program-specific WDs (Section 1.8). It is the objective of this DQO planning logic to identify the type, quality, and quantity of data needed to support these decisions and to help develop a comprehensive approach for acquiring these data.

Step 3: Identify Inputs to the Decision - The purpose of this step is to identify the informational inputs that will be required to resolve the decision statement and determine which inputs require environmental measurements. Key information includes objectives of WDs, the measurements that may be required, the source of data or information, and the basis for setting the activity and concentration levels used in this characterization.

Step 4: Define the Study Boundaries - The study area spatial boundaries include all of the potential contaminant migration pathways leaving the site (e.g., adjacent properties, air, surface water, ground water, and drainage systems). Study boundaries have been defined for each St. Louis site based on available data collected, but may be revised as new data are gathered.

Step 5: Develop a Decision Rule - The following decision rules summarize the attributes of the sample population and will determine the required quantity and quality of the data to be collected. The four primary elements to the decision rules are as follows:

1. **Parameters of Interest** - The parameters of interest to the sampling program are the MED/AEC-related PCOCs (see Table 1-1) across the sites in air, soil, sediment, ground

water, surface water and storm water, for which benchmarks have been derived to identify levels of environmental concern.

2. **Scale of Decision-Making** - The scale used for decision-making varies by decision. Each site is divided into IAs that should be addressed as a separate decision-making unit; thereby requiring separate sample sets for each IA. In addition, areas of the site considered to be "accessible" should be separated from "inaccessible" areas for evaluation purposes.

3. **Benchmarks** - The benchmarks should be defined for each sampling activity.

4. **Developing Decision Rules** - The decision rules for each of the decisions should be identified. These "if...then..." statements describe what action will be taken based on the results of the data collection.

Step 6: Specify Limits on Decision Errors - The benchmarks that are established may be used to distinguish potentially impacted areas from non-impacted areas. Detection limits are set accordingly and by the purpose for which the sample was taken (e.g., risk, and boundary delineation). The type of data and quality goals are specified to ensure that a data set is adequate to meet the task or program objectives.

Step 7: Optimize the Design for Obtaining Data - Biased and systematic sampling approaches are used to meet identified objectives. Details of the sampling strategy, selection of sampling locations, types of samples to be collected and optional sampling procedures are described in Section 2.0 of this report. Systematic or random systematic sampling approaches are used to:

1. Establish a grid for reconnaissance surveys including surface geophysical and gamma walkover surveys;
2. Select biased sampling points (soil media); and
3. Verify non-impacted areas outside of impacted areas.

Biased sampling is used to:

1. Define the maximum depth for waste volume calculations;
2. Determine whether radiological mixed waste is present;
3. Define the boundaries of impacted areas; and
4. Define the boundaries of non-impacted areas.

1.8 WORK DESCRIPTIONS (WDs)

WDs are proposed to implement specific remedial tasks or programs at the St. Louis FUSRAP Sites. The WDs may incorporate by reference, the sampling and analyses procedures, quality assurance, data management, and health and safety protocols defined in this SAG and should augment these protocols, as necessary. The WDs may be developed for specific sampling, investigation, remedial and monitoring activities and, therefore, only specific information necessary to complete the task or programs should be presented in the WD. The

USACE will authorize the WDs after submitting sufficient details for review prior to implementing the task or program.

WDs should include the following items (at a minimum) specific to the task or program activity:

- Purpose and scope of WD activity;
- Summary of previous or historical data and investigations, and a "current" status, specific to the WD;
- Identification and development of the project DQOs;
- Location and number of media samples and quality control samples according to specific data quality objectives;
- Specific analytical parameters for each media;
- Modifications to any sampling procedure or analytical protocol in the SAG with supporting justification for completion of the particular WD activity;
- Task-specific health and safety procedures including decontamination of equipment, PPE and identification of site-specific safety zones;
- Type of IDW anticipated and specific protocols for sampling and handling;
- Specific reporting and report format requirements including document/data review procedures;
- Schedule of WD activities to include all personnel and subcontractors; and
- Specific access agreements, permits, etc. (or reference) to complete the WD activity.

To summarize, this SAG will provide the standard operating procedures for completion and implementation of remedial monitoring activities at all St. Louis Sites under FUSRAP. WDs may provide specific technical guidance for completion of specific tasks or programs identified during the remediation activities at the St. Louis FUSRAP Sites.

2.0 FIELD INVESTIGATION APPROACH/SAMPLING ELEMENTS

This section identifies the approach to environmental investigation fieldwork, and specific field tasks of the SAG. General sampling objectives were described in Section 1.0. Detailed sampling objectives will be provided in task or program-specific WDs. This chapter provides the procedures and protocols for conducting many types of sampling elements that may be needed for the St. Louis Sites.

2.1 Stages of Investigation

Five major stages of investigation are defined by this SAG. These stages are:

Stage 1: Pre-mobilization/preliminary activities
Stage 2: Site reconnaissance
Stage 3: Data compilation and sample location selection
Stage 4: Intrusive sampling field activities
Stage 5: Verification survey/sampling

Each stage of work defines a set of work elements that provide data or information that may be used to refine or change certain work element components that will follow in subsequent stages of work. The 5 major stages are comprised of 13 work elements (tasks) described in Section 2.2. These work elements will be as identified by programs (e.g., EMG or EMI) or by specific WDs.

In accordance with the Observational Approach and the Adaptive Sampling and Analysis approach, decision-making authority remains with the USACE technical lead, but can be delegated to qualified personnel. Data are evaluated as they are collected and a decision to add or delete samples and sample locations is made, as necessary, to achieve the goals of an investigation. Contingency for additional sampling is included in the optimum or discretionary sample estimates that are generally provided in the project plan document, site-specific sampling plan, or WD.

2.1.1 Preliminary Activities/Mobilization

Stage 1 activities should be performed prior to mobilization of technical personnel to the site and may focus on reviewing available records, including design plans, facility records, areas/volumes of soil to be excavated, previous radiological survey data, former waste disposal and removal operations, location and distribution of site utilities. Current information such as accessible areas, ground-water levels, background chemistry of the soil and ground water in the local area, and climatic conditions (wind directions and intensity, rainfall, and temperature) should be evaluated. If needed, available and relevant historic information and/or photographs will be reviewed as deemed pertinent to each task. Stage 1 tasks may also include establishing necessary surveys and benchmarks and assessing site access requirements. In addition, surface geophysical surveys may be performed to identify the location of underground utilities, debris, fill areas, and other subsurface features.

Revision to the tasks included in Stage 2, as described below, may be made based on information gathered during Stage 1. For example, the final selection of the fixed background ambient air monitoring station may be made based on potential source areas and the least probable exposure areas upwind for the time of year when the samples will be taken. Density of walkover lines or areas to be evaluated by geophysical methods may be modified based on Stage 1 historical data. Selected soil or ground-water well locations may also be changed based on information collected during Stage 1 pre-mobilization activities.

2.1.2 Reconnaissance/Screening Activities

Stage 2 site reconnaissance survey activities should be performed by two- and three-person field teams. The following Stage 2 tasks can be performed concurrently with the mobilization of several field teams and support personnel, or may be run sequentially. The execution schedule for these tasks will be determined by level of funding and staff availability. Stage 2 work elements may include the following:

1. Surface electromagnetic (EM), magnetic and/or ground-penetrating radar (GPR) geophysical surveys. Use of additional methods may be based on the results of the EM surveys. The geophysical survey should be used primarily to define subsurface features to be considered during the remedial work. Geophysical screening techniques are presented in Appendix A.

2. Gamma walkover survey (GWS). High density surveys may also be performed either as a continuation of Stage 2 fieldwork or as part of the Stage 4 field program, based on the results of the initial gamma walkover survey. Within defined areas, in-situ gamma radiation measurements may be taken to help identify the lower limit of radiological concern. These measurements may be taken using a collimated High Purity Germanium (HPGe) [gamma] Spectroscopy tool. This equipment will provide quantitative, isotope-specific measurements of radionuclides present in a limited area of surface soils. Radiological screening technologies are presented in Appendix A.

3. Soil gas surveys, where appropriate. Soil gas survey technologies are presented in Appendix A.

4. Locating on-site meteorological monitoring stations and fixed background and mobile perimeter ambient air monitoring stations.

2.1.3 Data Compilation and Sample Location Selection

Data collected from Stage 1 activities and Stage 2 field reconnaissance will be integrated and interpreted during Stage 3. Compilation and integration of recent site data/plans and inspections, radiological surveys, soil gas, and geophysical surveys may be evaluated to establish the lateral boundaries for further investigation. Soil, sediment, surface water and ground-water well installation and sampling locations should be identified and adjusted, if necessary, based on the data from the reconnaissance surveys.

2.1.4 Intrusive Sampling Field Activities

Shallow depth and subsurface soil samples may be taken during Stage 4 activities. Supplemental background soil sampling from off-site locations is also anticipated. For IAs where known or probable impacted soils are present, a systematic approach should be used to define both the lateral and vertical boundaries for remedial efforts. Samples may be collected on a biased basis to define the vertical and lateral uncertainty of contaminants with an emphasis on defining the boundary between non-impacted and impacted soils. Fewer samples may be collected in areas where significantly elevated concentrations of contaminants are present and in areas which are apparently unaffected (i.e., to confirm the boundary). Soil samples may also be used to confirm waste classifications for disposal or to identify correlations with the field screening data that were collected during Stage 2. Precautions will be taken to prevent cross-contamination of penetrated zones.

New on-site, perimeter and background ground-water monitoring wells may be drilled, constructed, and sampled during Stage 4. In addition, selected wells may be identified for decommissioning. Selected wells may also be identified for piezometric surface monitoring. All boreholes will be described for stratigraphic definition and should undergo natural gamma logging.

Data collection will follow protocols established in this SAG and by USACE EM 200 and 1110 series guidance manuals (USACE, 1994b; USACE, 1994c). The QAPP and DMPP in Sections 3 and 4 will also provide QA guidance.

In general, field QC samples should be collected at a minimum frequency of 5 percent (i.e., 1 per 20 samples) for soil and ground-water samples. Field QC samples will include rinsate blanks (when applicable) and field duplicates. In addition, one source water blank should be submitted from the water used on-site for decontamination purposes. If the source of that water changes, then additional source water blanks may be submitted. Definitions/descriptions of QC samples are provided in the QAPP and are consistent with USACE EM 200 Guidance. QA (split) samples should also be collected at a frequency of five percent of the soil and ground-water samples. QA samples will be submitted to a laboratory identified in the QAPP.

Samples of waste material that could potentially be shipped to a commercial facility for disposal may be collected for full suite [VOCs, semivolatile organic compounds (SVOCs), metals, and radiological parameters] analysis, Toxicity Characteristic Leaching Procedure (TCLP) parameters, or for selected physical testing, as required by the selected disposal facility.

An on-site meteorological monitoring station may be constructed to initiate monitoring. Meteorological parameters to be monitored include wind speed and direction, ambient temperature, barometric pressure, precipitation, and evapotranspiration.

Ambient air monitoring stations may be established, and sampling conducted during Stage 4. Sampling conducted may be high volume air samples for total suspended particulate (TSP) and particulate matter with aerodynamic diameters less than or equal to 10 micrometers (µm) (PM_{10}), collected periodically throughout Stage 4. Units generally should operate one week prior to intrusive activities and one week after conclusion of Stage 4 activities. Collected samples may be analyzed for TSP, PM_{10}, gross alpha/beta, and metal parameters. Radon monitoring may also be conducted during Stage 4.

Ambient air monitoring of intrusive sampling activities should be conducted in accordance with the SSHP to verify compliance with applicable guidelines.

Sediment sampling of the Mississippi River should be conducted during low river levels and based on the results of Stage 3. Coldwater Creek sediment and surface water samples are anticipated to be needed for characterization, and risk-related issues. Storm-water samples for NPDES monitoring requirements are also expected during Stage 4.

Discretionary and biased surveying or sampling may be performed if the information derived during the preceding stages identifies data insufficiencies. The decision to increase the total number of samples will be at the discretion of the on-site technical lead.

2.1.5 Final Status Surveys

Final status surveys will be supported by this SAG and should be performed in cooperation with the remedial contractor following remediation of soil and to demonstrate attainment of cleanup criteria. Decisions to adjust sampling as a result of data obtained during Stage 4 of the investigation should be made with the decision team. Both radiological surveys and soil sampling may be required in accordance with the Radiological Final Status Survey (USACE pending) or, if chemical cleanup confirmation is required, appropriate USACE and EPA guidance may be followed. This sampling should be conducted in accordance with the guidelines and procedures further identified herein.

2.2 Work Elements

The following discussion provides detail on the work elements that are referenced in this SAG.

2.2.1 Geophysical Surveying

Geophysical techniques provide physical methods of determining subsurface features such as utilities, buried metal, and other objects which may be of concern during sampling and remedial activities. As such, geophysical techniques can provide indirect characterization of the subsurface where little information currently exists. EM, magnetic, and GPR surveys may provide information on the location of underground features and may be useful in performing remedial activities. A discussion of selected geophysical methods is also provided in Appendix A.

Interpretation of the geophysical data should be consistent with industry practices. The geophysical data will be correlated with available soil and well-log information. The correlation may result in refinement of the data processing or presentation, or both.

2.2.2 Downhole Logging

Some borehole geophysics may be performed in newly constructed wells. At a minimum, natural gamma logs should be performed in all new wells. The gamma log will provide lithology information since gamma response may be related to clay and silt content and permeability and may also provide information on deep radioactive contamination, if present. Gamma logging may be used in open (uncased) boreholes or in plastic- and metal-cased wells.

Boreholes should be logged according to American Society for Testing and Materials (ASTM, 1996) Standard D 5753-5 and USACE EM 1110-1-1802 for planning and conducting borehole geophysical logging.

2.2.3 Radiological Surveys

2.2.3.1 Gamma Walkover Surveys (GWS)

Among others, GWS may be used to detect the presence of gamma emitting radionuclides. GWS should be used in conjunction with systematic and biased sampling to verify interpretations of the data. Surveys will be performed using the appropriate gamma scan detector for the nuclides of concern. Global positioning system (GPS) may be used in conjunction with the gamma detector. This procedure will allow the location and measurement data to be downloaded for graphic visualization.

Acquisition of global positioning data should not begin until it is demonstrated that the positioning and post processing systems are capable of consistently providing coordinates that conform to the site grid within standard error of the positioning instrument or the desired accuracy for the specific survey. This demonstration should be made well before commencement of data acquisition.

2.2.3.2 In-Situ Gamma Spectroscopy

Following the gamma walkover surveys, in-situ gamma spectroscopy may be performed in areas of elevated gamma activity as defined by the walkover surveys. In-situ gamma spectroscopy may be used to measure average isotope-specific concentrations of radionuclides integrated over a specific area. The instrument, which uses a high purity germanium crystal as a detector, will be collimated to measure the spectrum of emitted gamma activity in an area to be determined in the field. The areas are limited to the following as determined by the calibration model: a circle with an area of 25, 50, 75 and 100 m^2. These data measurements should allow a better definition of poorly defined walkover boundaries and better correlations between walkover data and verification of remediation.

2.2.4 Soil Gas Surveys

Soil gas surveys may be used as a screening tool to identify any source areas of VOCs. Where appropriate, this passive soil gas survey procedure should be completed prior to additional on-site soil and ground-water sampling events in order to target soil sampling locations for VOC analyses.

The basic sampling procedure includes identifying sampling locations on a predetermined grid pattern generally less than 30 m (100 ft). These locations are flagged and located by geopositioning techniques for mapping and sample retrieval purposes. At each passive soil gas sampling location, an absorbent media will be placed a few inches beneath the soil and allowed to absorbed VOCs from the soil gas for a few days. Following that period of time, the absorbent media will be retrieved and placed into glass vials supplied by the laboratory. The sample media should then be submitted to a laboratory for analysis of VOCs by SW-846 Method 8260. Procedures for installation, retrieval, and analysis of these samples are provided in Appendix A (Screening Procedures). Additional sampling points may be required between the proposed sampling points or outside of the proposed sampling grid in order to map source areas or better delineate the edge of a source area.

2.2.5 Meteorological Monitoring

On-site meteorological monitoring is anticipated with the installation and setup of an on-site meteorological station during Stage 2 or 3. Meteorological parameters to be monitored include wind speed and direction, ambient temperature, barometric pressure, precipitation, and evapotranspiration. The site-specific meteorological data may be used to correlate site conditions to local National Weather Service stations with long-term historical data and river stage monitoring. The site-specific meteorological data may also be used to support environmental monitoring during site remediation. In addition, meteorological conditions can affect various radiological and geophysical screening equipment, and continuous monitoring of climatic changes is necessary to properly calibrate this equipment for the duration of the field activities. Monitoring protocols will be based on EPA guidance for meteorological monitoring. The monitoring points will be surveyed or located using geopositioning techniques, following identification during Stage 2.

2.2.6 Ambient Air Monitoring

Ambient air particulate monitoring is important to verify that off-site locations are not impacted during site remediation activities. Particulate monitoring results collected at site perimeters may be compared to area background concentrations and applicable standards. FUSRAP is required to comply with the applicable regulations identified in the CFR, Title 40, Part 61, Subpart I and 10 CFR 20, Appendix B (Table 2, Column 1).

Particulate monitoring includes sampling for both TSP and less than 10 micron particulate material (PM_{10}). Collected samples may be analyzed for TSP, PM_{10}, gross alpha/beta screening, and metal parameters. Field screening for total gross alpha/beta counts should be performed using either a Ludlum 4310 zinc scintillator detector with Ludlum 2929 alpha/beta scales, or an automated gas flow proportional counter.

To establish a data correlation between the area background and site locations, two ambient air monitoring stations are recommended. One fixed station should be sited to establish background concentrations. This station should be generally located upwind from the site and away from point sources of particulates. The second station should be mobile and sited each day of sampling to monitor ambient air at the site perimeter in the prevailing wind direction. The siting of the background monitoring station will take into account prevailing wind direction, proposed remedial activities, proximity to other potential sources, and availability of utilities.

Final locations for the fixed station and downwind sites will be field verified during Stages 1 and 2. Air sampling points will be surveyed or located using geopositioning techniques.

Sampling conducted at the ambient air monitoring stations may consist of 24-hour high volume air samples for TSP and PM_{10}, collected every other day throughout Stage 4. Samples collected should be analyzed for TSP, PM_{10}, gross radiological activity, and metal parameters. Table 2-1 identifies the sample container requirements for air and direct radiation monitoring. Total gross alpha/beta will be sampled in accordance with Appendix B to the 10 CFR 20. Particulate sampling protocols will be based on Reference Methods presented in Appendices B and J to the 40 CFR 50, National Ambient Air Quality Standards. Analytical protocols for gross radiological constituents are referenced in the QAPP and will be conducted using portable field detectors or the on-site FUSRAP laboratory.

2.2.7 Sediment and Surface Water Sampling

Sampling sediments of the Mississippi River or Coldwater Creek or other sediments may be needed to confirm previous sampling results or provide boundary data for remedial action. The protocols that should be implemented for the collection of sediment samples are described in detail in the USACE Environmental Sampling Instructions (Appendix C, Section C-5, EM-200-1-3). Sampling of Mississippi River sediments should be conducted during low river levels, as determined by river gaging data. This procedure should allow collection of samples with the use of a scoop, trowel, or tube sampler. The use of boats will be avoided, if possible. Sediment samples will be collected into the appropriate containers identified in Table 2-2.

Surface water samples may be collected to monitor impacts from FUSRAP Sites. Specific locations will be identified in the monitoring plans to acquire data for the specific objectives. Surface water samples will be collected into the appropriate containers identified in Table 2-3.

2.2.8 Storm-water and Wastewater Discharge Sampling

Storm-water runoff is being sampled at SLAPS and HISS to comply with NPDES permit requirements. No storm-water sampling presently exists at SLDS. It is anticipated that remedial actions at any site may result in wastewater discharges that may need to be covered under NPDES permits. Monitoring under these permits will be incorporated in the EMG through the annual revision process.

The specific sampling location (outfalls) and analytes targeted for monitoring are specified by existing MDNR operating permits. The baseline sampling frequencies and parameters will be a component of the annual evaluation of EMG data. Based on the evaluation, sampling frequencies or parameters may be altered to meet new technical objectives or permit requirements. Storm-water and wastewater samples should be collected into the appropriate containers identified in Table 2-3.

Table 2-1. Container Requirements for Air and Direct Radiation Monitoring

Analyte Group	Container[1]	Preservative	Holding Times
External Gamma	Thermoluminescent Dosimeter	None	Hold times for external gamma detectors shall be 30 days in order to minimize dosimeter fade.
Rp-220 Rn-222	Alpha-track Detector	None	The manufacturer recommends that the alpha track detectors be analyzed within two weeks after the sampling period.
Radon flux	Radon Flux Carbon Canisters	None (do not expose to heat)	The minimum holding time for radon flux samples is four hours. The maximum holding time is three days. Therefore, samples should be analyzed between 4 and 72 hours after removal from the pile as radon may begin to desorb from the charcoal.
Air Particulate Isotopic U, Th	Filters	None	Holding time for the particulate samples shall be 90 days. The nuclides examined in this procedure are long-lived; thus, sample deterioration is not a concern.

[1] In general, for air samples and direct radiation monitoring, the collection device (i.e., detector) serves as the sample container. All detectors can be shipped in fiberboard boxes.

Table 2-2. Container Requirements for Soil and Sediment Samples for St. Louis FUSRAP Investigations

Analyte Group	Container	Minimum Sample Size	Preservative	Holding Time
Volatile Organic Compounds	1 – 125 ml (4 oz) glass jar with Teflon®-lined cap	5 g	Cool, 4°C	14 d
Semivolatile Organic Compounds	1 – 250 ml (8 oz) glass jar with Teflon®-lined cap	90 g	Cool, 4°C	14 d (extraction) 40 d (analysis)
Pesticides/polychlorinated biphenyls (PCBs)	use same container as SVOCs	90 g	Cool, 4°C	14 d (extraction) 40 d (analysis)
Metals	1 – 125 ml (4 oz) wide mouth plastic or glass jar	20 g	Cool, 4°C	180 d, Hg at 28 d
Leachable Anions	use same container as metals	10 g	Cool, 4°C	28 d
Radiochemical Parameters	1 – 500 ml (16 oz) wide mouth glass jar with Teflon®-lined cap	500 g	None	180 d
Geotechnical Parameters	Shelby tube	NA	None	None
Waste Characteristics	1 – 500 ml (16 oz) wide mouth glass jar with Teflon®-lined cap	1000 g	Cool, 4°C	general 14 d

Table 2-3. Container Requirements for Surface Water Samples for St. Louis FUSRAP Investigations

Analyte Group	Container	Minimum Sample Size	Preservative	Holding Time
Volatile Organic Compounds	2 - 40 mL glass vials with Teflon®-lined septum (no headspace)	40 mL	HCL to pH <2 Cool, 4°C	14 d
Semivolatile Organic Compounds	2 - 1L amber glass bottle with Teflon®-lined lid[a]	1000 mL	Cool, 4°C	7 d (extraction) 40 d (analysis)
Pesticides/PCBs	3 - 1L amber glass bottle with Teflon®-lined lid[a]	1000 mL	Cool, 4°C	7 d (extraction) 40 d (analysis)
Metals	1 - L polybottle	500 mL, metals 200 mL, Hg	HNO_3 to pH <2 Cool, 4°C	180 d, metals 28 d, Hg
Nitrate- Nitrite, Ammonia, Phosphate	500 mL polybottle	100 mL each	H_2SO_4 to pH <2 Cool, 4°C	28 d
TOC	125 mL polybottle	50 mL	H_2SO_4 to pH <2 Cool, 4°C	28 d
Sulfide	500 mL polybottle	200 mL	zinc acetate plus NaOH to pH >9 Cool, 4°C	7 d
TRPH	1 - L glass bottle	1000 mL	H_2SO_4 to pH <2 Cool, 4°C	28 d
Alkalinity/TSS/TDS	1 - L polybottle	100 mL ea.	Cool, 4°C	7 d
Radiochemical Parameters	2 - gal plastic container[a]	4 L	HNO_3 to pH <2	180 d

[a] One investigative water sample in twenty will require an additional volume for the laboratory to perform appropriate laboratory QC analysis. [i.e., matrix spike/matrix spike duplicate (MS/MSD)].

2.2.9 Soil Sampling Strategies

The protocols that should be implemented for the collection of soil samples (surface soil and borings) are described in detail in the USACE Environmental Sampling Instructions (EM 200-1-3). Surface soil samples should be collected using the spade-and-scoop method. The shallow soil samples may be collected using either 76 millimeters (mm) (3 in) diameter continuous split spoons, the central mine equipment (CME) continuous barrel sampler, a direct-push technique, or the manual methods described in the EM 200-1-3 manual. The deeper, soil boring samples may be collected using a carbon or stainless steel split-spoon sampler direct-push technique, or CME continuous barrel sampler. All methods are described in the USACE Environmental Sampling Instructions manual, with the exception of the direct-push method.

With the spade-and-scoop method, the top layer of soil to the desired sample depths is removed with a pre-cleaned or decontaminated spade. A pre-cleaned, stainless steel scoop or trowel is then used to collect a sample from the desired depth. The split-spoon sampler usually requires a hollow-stem auger drill rig. A 7.62 centimeter (cm) (3 in) diameter, thick wall split spoon that is split lengthwise will be used. When a boring is advanced to the point at which the sample is to be taken, a split spoon is lowered through the hollow augers to the sample collection depth. The sampler is then driven into the ground in accordance with the standard penetration test. The split spoon is then withdrawn from the borehole, the drive shoe and head are removed from the sampler, and the sampler is split lengthwise to expose the soil. The CME sampler or the continuous barrel sampler collects samples in 1.5 m (5 ft) increments. The split barrel sampler is used in conjunction with the hollow-stem auger rig. The 4 in diameter sampler fits inside the lead hollow-stem auger and collects soil as the auger is advanced into the soil. The sampler is then withdrawn from the boring and opened in a similar fashion to the split spoon sampler. The direct-push technology sample collection method involves a Geoprobe® and a 0.6 m or 1.2 m (2 ft or 4 ft) long stainless-steel sample tube. The stainless-steel sample tube is fitted with a disposable, internal acetate liner and then equipped with a cutting shoe that is pushed into the ground. The tube is then retrieved from the ground, the cutting shoe is removed, and the internal acetate liner is removed from the stainless-steel tube. The acetate liner is then cut lengthwise with a pre-cleaned, stainless steel knife. Soil samples for laboratory analysis will be collected into the appropriate containers identified in Table 2-2.

The protocols for sample handling, preservation, tracking, and shipping are presented in both the USACE Environmental Sampling Instructions (Appendices C and D) and the QAPP (Section 3.0) and DMPP (Section 4.0). During the removal of soil from the sampling device, the order of collection for analytical parameters will be organics, metals, and then radionuclides. In general, to maintain integrity of the collected samples, preservation techniques should include refrigeration and protection from light, and the sample jars should be closed as soon as possible after filling. Gloves will be donned immediately prior to sampling, and a clean pair of new disposable gloves will be worn each time a different location is sampled. For further minimization of cross-contamination, samples containing low and high concentrations of contaminants should be placed in separate plastic bags immediately after collection, preserving, and tagging. All sampling equipment that contacts the soil during collection activities will be decontaminated between sample collection points.

The location of all proposed borings and soil sampling points should be flagged and field located using GPS prior to sampling, and will be identified in Missouri State plane coordinates. All borings will be logged and described by a geologist or soil scientist in accordance with geologic description guidance provided in Chapter 13 and Appendix E of EM-1110-1-1906 (USACE, 1996a). Each soil collection interval will be identified and classified according to the Unified Soil Classification System (USCS) presented in the Logging Manual. The soil descriptions will be documented on the Hazardous, Toxic, and Radioactive Waste (HTRW) drilling log.

Each soil sample collected should be screened in the field for beta-gamma activity and total VOCs prior to sample handling. Calibration procedures for the radiation and organic vapor detectors are presented in the QAPP (Section 3.0). These readings will also be recorded on the appropriate log.

Surface soil [from the surface to a depth of 15 cm (6 in) bgs] and select shallow subsurface soil samples [at depths of 0.6 m and 1 m (2 ft and 3 ft) bgs] may be collected within areas that were excavated to remove contaminated soil above DCGLs in accordance with removal plans. The surface soil locations and grid patterns are defined in the final status survey for the respective remediation sites. The following protocol is consistent with USACE Environmental Sampling Instructions (USACE EM-200-1-3, Appendix C-6) and is provided specifically for soil sampling for verification.

2.2.9.1 Sampling Equipment

The primary equipment to collect surface soil samples consists of a stainless steel coring tool commonly used by golf courses (ASTM C-998). This equipment has approximately a 10.5-cm diameter barrel and can collect samples down to 30 cm (12 in) bgs. The outside of the barrel can be marked to collect surface soil samples to a depth of 15 cm (6 in) bgs. This sampler is very effective with relatively fine-grained soils and a lack of appreciable coarse fragments greater than 6.35 mm (¼-in). Several core samples can be collected easily in the same sampling location to obtain the required volume of sample for chemical analyses.

An alternate piece of equipment to collect surface soil samples will be a stainless steel scoop. The scoop may be use for soil that is non-cohesive or contains a relatively high percentage of coarse fragments. The scoop can be used to collect a uniform soil sample to a depth of 15 cm (6 in) bgs at the designated sampling location under the loose (non-cohesive) soil conditions.

At the shallow subsoil sampling locations, the surface soil may be removed with hand bucket auger [approximately 12.5 cm (5-in) diameter] or spade to a depth of approximately 30 cm (1 ft) above the target sampling depth of 0.6 m or 1 m (2 ft or 3 ft). The auger bit can be replaced with a tube corer attachment and driven into the soil and the core retrieved to collect the sample. A separate stainless steel sampling tube could also be driven into the soil at the bottom of the auger hole. Additional core samples can be collected within the same auger hole to collect a sufficient volume of soil to perform the required analyses.

2.2.9.2 Sample Description/Classification

The acquired soil samples will be identified and classified according to the USCS. Soil and geologic material should be handled, identified and recorded in accordance with the guidance provided in Chapter 13 and Appendix E of EM-1110-1-1906 (USACE, 1996a). At a minimum, the location identification, depth interval, sample texture and estimated percentage (by volume) of coarse fragments will be recorded on the logging form. Results of sample screening for radiological and VOC parameters should also be included.

2.2.9.3 Sampling Methods

Soil Coring Method or Scoop – Surface Soil Samples [to 15 cm (6 in) bgs]

- Place plastic sheeting on the ground around the sampling location.
- Using a precleaned or decontaminated stainless steel soil coring tool (or stainless steel scoop), collect a grab sample for VOC analysis first (if required) and proceed to composite the remainder of the sample in a stainless steel bowl for the remaining analytical parameters (refer to USACE Sample Manipulation Instructions, EM 200-1-3, Appendix E, Section E-3).
- For radionuclide analyses, collect ½ to 1-liter (L) volume of soil. For total VOC, total SVOC, total metals and total PCBs/herbicides/pesticides, collect an additional 1 L of soil into the appropriate containers (see Table 2-2).
- Label the sample bottles using the sample identification system provided in Section 3.3. A sequential Sample Number will follow the Site Designator code to identify the samples for collection and delivery to the laboratory.
- Complete all chain-of-custody documents using the form identified in Section 3.4.1 and record the sampling event in the field logbook (refer to USACE Sample Documentation and Shipment Instructions, EM-200-1-3, Appendix F).
- Decontaminate sampling equipment after use and between sample locations (refer to USACE Sample Manipulation Instructions, EM-200-1-3, Appendix E).

Hand Auger/Tube Sampler – Subsurface Soil Samples [0.6 m or 1 m (2 ft or 3 ft) bgs]

- Place plastic sheeting on the ground around the sampling location.
- Using the bucket auger, hand auger to a depth equal to ½ of the length of the sample probe above the target depth of 0.6 m or 1 m (2 ft or 3 ft). Remove accumulated soil from around the auger hole to prevent loose soil from falling back into the borehole.
- Remove the auger bit from the hand auger and attach the precleaned or decontaminated stainless steel coring probe (or use a separate precleaned or decontaminated stainless steel coring probe) and carefully lower the probe into the auger hole. Take care to avoid scraping the sidewalls of the auger hole. Push corer into the bottom of the hole to the full depth of the probe.
- Remove the probe and collect the soil sample and discard the top [approximately 2.5-cm (1 in)] which represents any material collected by the probe before the target soil layer.
- Collect a grab sample for VOC analysis first (if required) and proceed to composite the remainder of the sample in a stainless steel bowl for the remaining analytical

parameters (refer to USACE Sample Manipulation Instructions, EM 200-1-3, Appendix E, Section E-3).

- For radionuclide analyses, collect ½ to 1-L volume of soil. For total VOC, total SVOC, total metals and total PCBs/herbicides/pesticides, collect an additional 1 L of soil into the appropriate containers (see Table 2-2).
- Label the sample bottles using the sample identification system provided in Section 3.0 of this SAG. A sequential Sample Number will follow the Site Designator code to identify the samples for collection and delivery to the laboratory.
- Complete all chain-of-custody documents using the form identified in Section 3.4.1 and record the sampling event in the field logbook (refer to USACE Sample Documentation and Shipment Instructions, EM-200-1-3, Appendix F).
- Decontaminate sampling equipment after use and between sample locations (refer to USACE Sample Manipulation Instructions, EM-200-1-3, Appendix E, Section E-5).

Hollow-Stem Auger, CME Sampler, or Geoprobe® - Subsurface Soil Samples [> 1 m (3 ft) bgs]

- Place plastic sheeting on the ground near the sampling location.
- Auger or direct push the sampling probe to a depth above the target depth. Remove accumulated soil from around the auger hole to prevent loose soil from falling back into the borehole.
- Place a precleaned or decontaminated split spoon inside the hollow stem auger or the samplers for the CME and Geoprobe® and carefully lower the samplers into the hole. Take care to avoid scraping the sidewalls of the auger hole. Push sampler into the bottom of the hole to the full depth of the probe.
- Remove the sampler and split the spoon or cut the liner insert with a clean stainless steel knife and collect the soil sample. Discard the top [approximately 2.5-cm (1 in)] which represents any material collected by the probe before the target soil layer.
- Collect a grab sample for VOC analysis first (if required) and proceed to composite the remainder of the sample in a stainless steel bowl for the remaining analytical parameters (refer to USACE Sample Manipulation Instructions, EM 200-1-3, Appendix E, Section E-3).
- For radionuclide analyses, collect ½ to 1-L volume of soil. For total VOC, total SVOC, total metals and total polychlorinated biphenyl (PCBs)/herbicides/pesticides, collect an additional 1 L of soil into the appropriate containers (see Table 2-2).
- Label the sample bottles using the sample identification system provided in Section 3.0 of this SAG. A sequential Sample Number will follow the Site Designator code to identify the samples for collection and delivery to the laboratory.
- Complete all chain-of-custody documents using the form identified in Section 3.4.1 and record the sampling event in the field logbook (refer to USACE Sample Documentation and Shipment Instructions, EM-200-1-3, Appendix F).
- Decontaminate sampling equipment after use and between sample locations (refer to USACE Sample Manipulation Instructions, EM-200-1-3, Appendix E, Section E-5).

2.2.10 Background Reference Area Soil Sampling

In accordance with the guidance provided in MARSSIM (EPA, 1997), adequate background reference soil data are needed for comparison with radiological final status surveys, including target sample depths and associated statistical criteria. The locations may be identified according to available access within those areas considered representative of the soils in the areas to be remediated. The target sample depths will be the surface 0 to 15 cm (0 to 0.5 ft) depth and the 0.6 to 1 m (2.0 to 3.0 ft) depths at each location. Radionuclides will be analyzed for all samples. Additional analyses for chemical parameters may also be conducted and statistical methods for data manipulation will follow USACE and EPA guidance. In general, field QA and QC samples will be collected in accordance with guidelines provided in the QAPP (Section 3.0).

2.2.11 Soil Sampling for Remedial Investigation and Design

Soil sampling for remedial investigations includes collecting soil samples from various depths over potentially impacted areas to characterize the scope and extent of constituents of concern. Soil samples at the St. Louis FUSRAP Sites may be collected for radionuclides and chemical parameters, including VOCs, SVOCs, pesticides, herbicides, PCBs, and target analyte list (TAL) metals. TCLP analyses are performed on selected soil samples for disposal decisions. The data collected from these investigations are used to support risk assessment evaluations and provide limits on the extent of impact that may guide potential removal activities.

2.2.12 Soil Sampling for Remedial Confirmation/Final Status Surveys

Final status survey soil sampling is performed to verify the remediation and/or removal of contaminated soil materials to applicable remediation standards. The protocol generally follows MARSSIM guidance for radiological parameters or other guidance as referenced throughout this section for chemical parameters. The final site verification will document if the cleanup goals have been met, as established for each site. Final status surveys identify the collection of soil samples from the surface of excavations and, therefore, surface soil sampling procedures should be used.

2.2.13 Sampling of Waste Materials for Commercial Disposal

The soils in the remedial areas may contain non-radiological constituents or debris and could potentially be classified as hazardous. Once the remedial areas are identified, several representative samples of these wastes may need to be collected to characterize them for off-site disposal. Samples of IDW, such as soil/rock cuttings and decontamination fluids, may also require sampling and analysis for waste characterization. Knowledge of site-specific processes and historical chemistry may be used to complete waste characterization profiles. These wastes will be shipped to a designated off-site disposal facility, as necessary.

The exact number of waste characterization samples is dependent on the number of proposed areas of excavation and the method of IDW handling. A portion of these samples may be submitted for the following analyses:

1. Gamma spectroscopy (natural and man-made isotopes);
2. Uranium and thorium isotopes;
3. TCLP (8 metals and 32 organics) plus copper and zinc; and
4. Soil pH/paint filter liquids test.

In addition, several supplementary parameters may need to be analyzed from the samples to complete the Radioactive Waste Profile Record. These additional parameters include the following:

1. Particle size (305 mm [12 in], 102 mm [4 in], 25 mm [1 in], 6 mm [¼ in], 6 µm [1/40 in], and 1 µm [1/200 in]);
2. Density;
3. Moisture content (ASTM D-698);
4. Ignitability; and
5. Reactivity.

The proposed waste sampling procedures involve collecting grab samples for volatile organic constituents and composite samples for the other constituents. Grab samples for organics analyses may be collected directly from the sampling tool, while the remaining material should be placed into a stainless-steel bowl for compositing. Sample collection will be conducted in accordance with the sampling methods presented in Section 2.2.13, and sample handling will be conducted in accordance with the project QAPP.

If additional discrete areas of soil for off-site disposal are identified at the site, additional characterization samples may be necessary. The number of waste characterization samples should be selected according to the volume and requirements of the intended receiving facility. If debris materials are encountered within the areas targeted for off-site disposal, swipe testing of the debris may also be required in accordance with RCRA guidelines.

2.2.14 Sampling for Determination of Geotechnical Properties/Modeling Parameters

Some physical properties of unconsolidated deposits may be needed for remedial design purposes. Core-like recovery (using split spoon, Shelby, continuous barrel, or core barrel samplers according to EM-200-1-3 guidance) should extract a continuous record of substrate to the desired target depth in each boring. This work element should confirm the local stratigraphy at each new well location. The substrate at each boring/well location will be described relative to depositional features, moisture, grain size, compaction, and other field parameters. The physical and morphological properties of the material will be documented in accordance with geologic description guidance provided in Chapter 13 and Appendix E of EM-1110-1-1906 (USACE, 1996a). A separate representative sample of soil/sediment core material from the target depth may be collected for laboratory analysis. Geotechnical determinations may include porosity, permeability, hydraulic conductivity (hysteresis curves), percent moisture, bulk density, total organic carbon, and particle size. A summary of the geotechnical parameters and methods is provided in Table 2-4.

Table 2-4. Analytical Parameters and Methods for Geotechnical Evaluation

Parameters	Analytical Methods
	Soil/Sediment/Waste
Physical Testing	
Soil Hydraulic Conductivity	ASTM D-5084-90
Porosity	ASTM E-1294
Permeability	ASTM D-698-91
Plasticity	ASTM D-4318-84
Particle Size	ASTM D-422-63
Moisture Content	ASTM D-2216-90[1]
Bulk Density	ASTM D-5057[1]

ASTM - American Society for Testing and Materials

[1] ASTM standards, Volume 04.08, Soil and Rock, 1995, and Volume 11.04, Water and Environmental Technology, 1993.

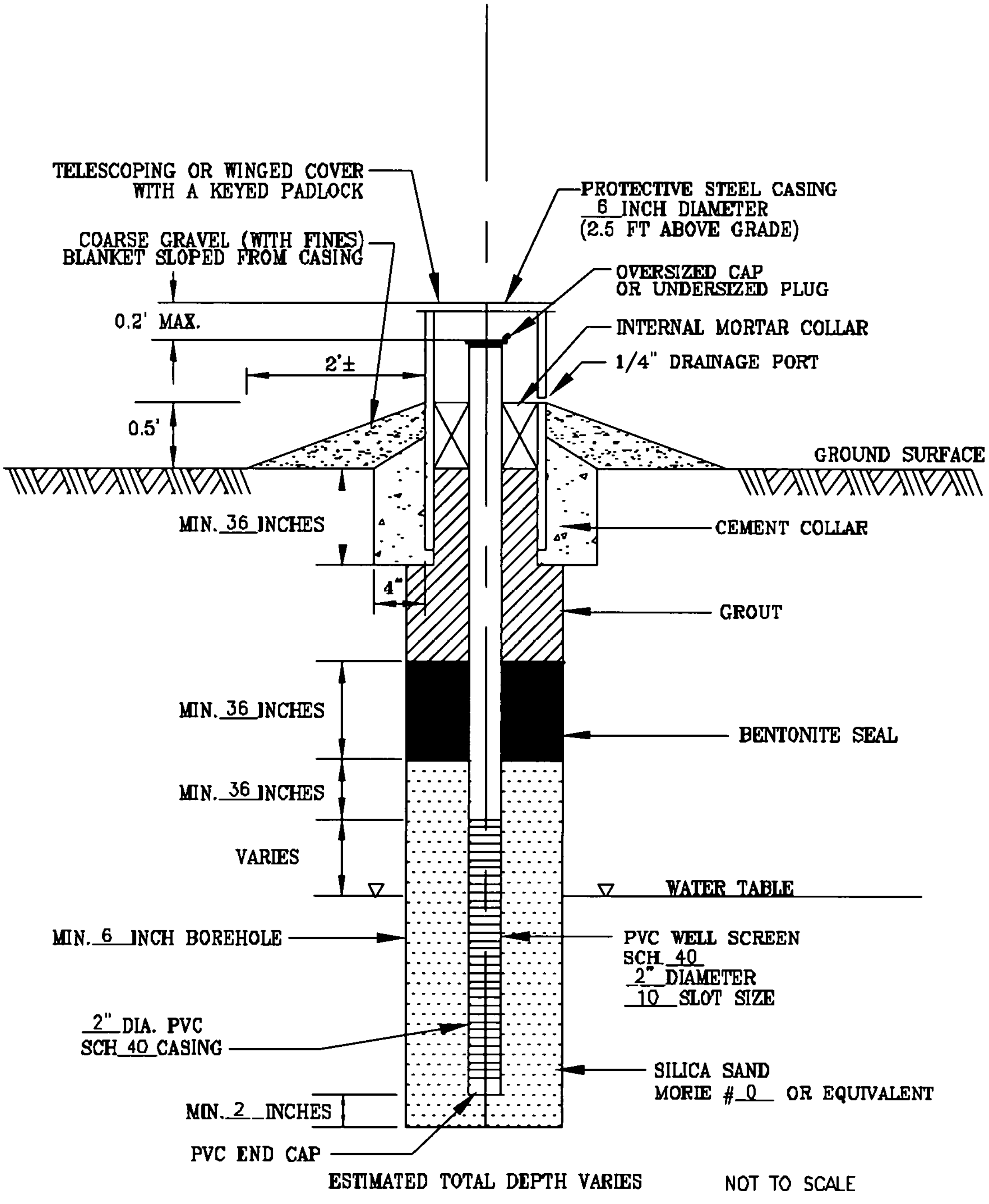
2.2.15 New Well Installation

New well locations may be needed to better define piezometric surfaces and ground-water flow direction; determine background ground-water quality; further define the impacts of radionuclide, metal, or chemical constituents in the ground water; and provide additional points for perimeter compliance monitoring.

Well borings greater than or equal to 3 m (10 ft) bgs may require permits from MDNR in accordance with the Code of State Regulations (CSR) well permitting regulations (10 CSR 23). A Missouri registered geologist must supervise drilling and well installation activities.

The typical well construction detail of a shallow monitoring well [up to depths of 7.6 m (25 ft) bgs] is shown on Figure 2-1. The typical well construction details for a deep well is shown on Figure 2-2. The rationale for the placement and final construction specifications of new monitoring wells will be provided in task-specific WDs.

For well installation, a minimum 15 cm (6 in) diameter borehole should be made using rotary-drill, cable tool, or hollow-stem auguring methods. Double casing methods will be used for the deep wells or where special precautions are warranted to avoid downward contaminant migration. For the double cased wells, an outer casing [probably 15 cm (6 in) diameter steel casing] should be placed into a 25 cm (10 in) diameter borehole to a depth of 1 m to 1.5 m (3 to 5 ft) into the restricting layer. This casing will be grouted in place prior to any further drilling. This casing placement for a deep monitoring well is shown on Figure 2-2.



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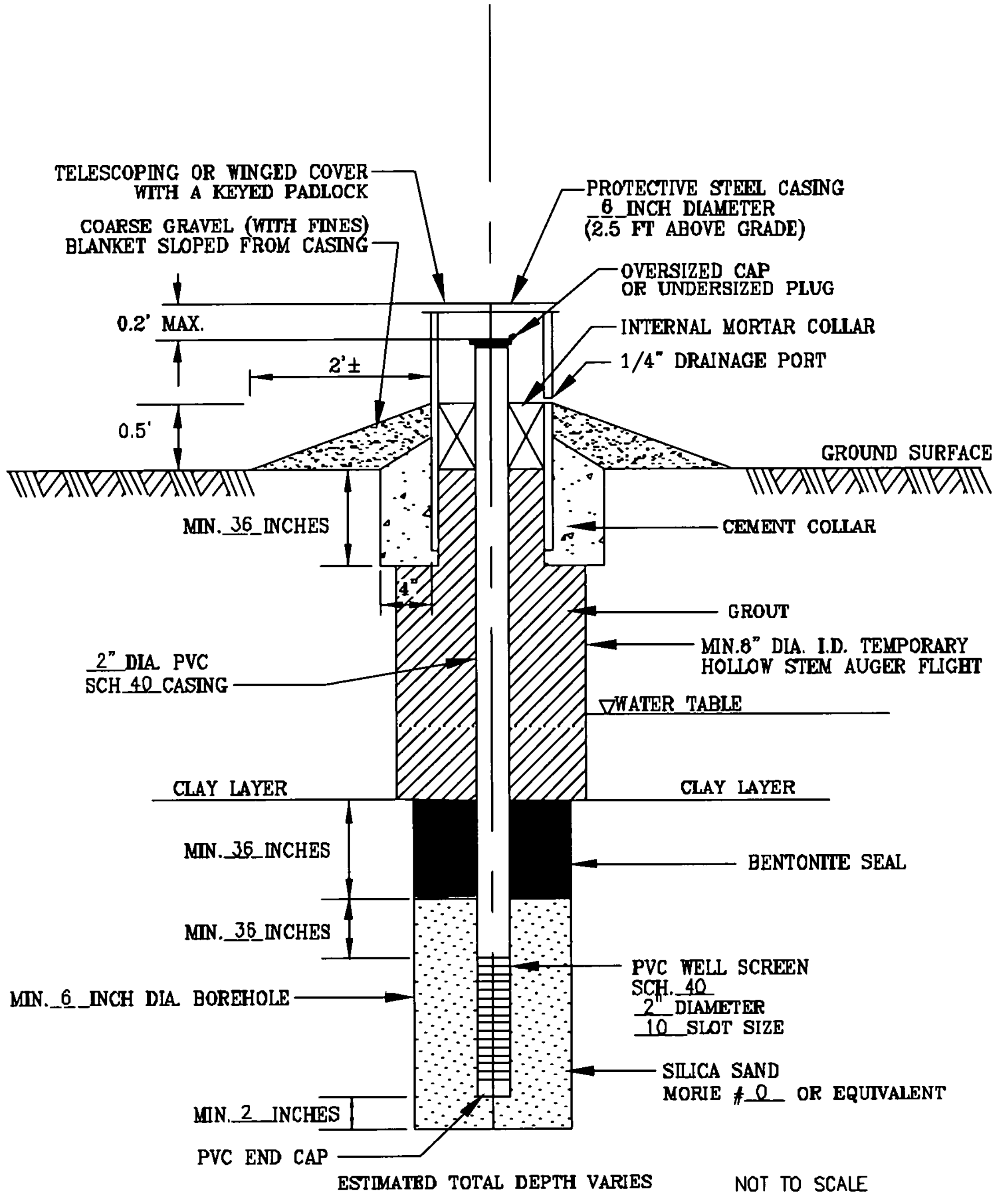
FUSRAP

St. Louis Site

St. Louis, Missouri

DRAWN BY:	REV. NO./DATE:
S. Kitchings	0 - 08/01/00

Figure 2-1. Typical Shallow Monitoring Well Construction



FUSRAP

St. Louis Site

St. Louis, Missouri

DRAWN BY:	REV. NO./DATE:
F. Bauer	0 - 08/01/00

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Figure 2-2. Typical Deep Monitoring Well Construction

The drilling and sampling of subsurface materials and the installation of ground-water monitoring wells will be completed in accordance with protocol and specifications of USACE Manual EM 1110-1-4000 (USACE, 1994b) and Code of State Regulations (CSR), Title 10 Division 23. The Monitor Well Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites manual (USACE, 1994b) provides the basic elements for consideration for monitoring well work such as drilling operations, borehole logging, and well installation. The soil/rock cutting and fluids produced by the drilling and installation of new wells should be managed as IDW.

Soil samples should be lithologically described and archived for potential analysis or geotechnical evaluation. Each split-spoon sample will be described by a geologist or soil scientist in accordance with geologic description guidance provided in Chapter 13 and Appendix E of EM-1110-1-1906 (USACE, 1996a) and may be screened with a radiation detector and a total organic vapor analyzer (OVA). Observations and screening measurements will be recorded on the drilling log. Stratigraphic analysis at each well location is critical to determine the total depth of a well in a particular zone and the appropriate construction (e.g., screened interval). A natural gamma geophysical log should be acquired in each well borehole prior to well construction.

All wells should be constructed using 5 cm (2 in) diameter polyvinyl chloride (PVC) screen and riser pipe. The slotted screen for water surface well completions will be 3 m (10 ft) in length with a screen slot size and sand pack material determined according to site-specific geologic conditions (see EM-1110-1-4000). The length of screen may be shortened in a well for deep well completions or if the desired screened zone is less than 3 m (10 ft) thick. The well screen in water surface wells should be placed to straddle the ground-water surface. The screened intervals will be packed with appropriate sized sand by use of a tremie pipe. A minimum 1-m (3-foot) bentonite seal will be placed above the sand pack. Bentonite pellets should be used to form the seal below the water surface, and granular bentonite should be used for seals above the water surface.

The annular seal, comprised of an appropriate grout must be placed from the bentonite seal to the base of the protective casing. A high solids bentonitic slurry-grout (20%-30% by weight solids) should be used so that the grout remains flexible [that is, to accommodate freeze-thaw and resist cracking via soil movement] during the life of the installation. The mixing (and placing) of a grout should be performed with precisely recorded weights and volumes of materials, and according to procedures approved by USACE and MDNR (per 10 CSR 23-1.040). Strenth Grout will be used as an alternate to the bentonitic slurry-grout when directed by the USACE. Strength Groutwill be placed from the bentonitic seal to the ground surface. Table 2-5 provides the approved backfill types for monitoring wells and exploration borings. A side-discharging tremie pipe will be used for all grout placement, starting from the bottom to the top of the annular space in one continual operation. A protective steel casing with a locking cap or flush-mounted drive-over manhole will be installed on each well. The drilling and installation procedures and materials for these wells will comply with the requirements of USACE Manual EM-1110-1-4000, Chapters 3, 4, 5, and 7, and other applicable guidance.

Table 2-5. Backfill for Monitoring Wells and Exploration Holes

Boring Type	Boring Depth, d in feet	Typical Location	USACE-directed Special Location
Monitoring Well Original Placement	all	High-solids Bentonitic Slurry-Grout for the annulus above the plug	Strength Grout for the annulus above the plug
Decommissioning of a Monitoring Well	all	High-solids Bentonitic Slurry-Grout for backfill+	Strength Grout for backfill+
Exploration Holes	d < 4.0'	Bentonitic chips+	Native Soil
Exploration Holes	3.9' < d < 10.0'	Bentonitic chips+	Strength Grout for backfill+
Exploration Holes	d > 9.9'	High-solids Bentonitic Slurry-Grout for backfill+	Strength Grout for backfill+

d symbol for Boring Depth.

+ Depending upon the type of surrounding surface, either a base course and pavement should be placed to match the site, or alternatively, the two feet nearest the surface requires native soil for backfill as a growing medium.

Well development will be completed for the new wells in accordance with USACE Manual EM 1110-1-4000 protocol, Chapter 6. Well development will commence after the grout around the well has cured for at least 48 hours. Each well will be developed at least 14 days prior to commencement of ground-water sampling to remove drill cuttings and fine sediment in the sand pack, maximize well yield, and restore hydraulic conductivity after well installation. The well development process may include pumping, bailing, and surging methods. A bailer will be raised and lowered throughout the screened zone of the well. The well will then be pumped until the water is clear or other criteria are met. Potable water may be added to low-yielding wells to enhance the development process. Compressed air will not be used as part of the development process. The volume of added water (if any) will be recorded and removed from the well. The development process will be completed when the turbidity of the well is as low as possible [below 50 nephelometric turbidity units (NTUs)] and minimal sediment [less than 3 cm (0.1 ft)] remains at the well bottom. Field parameters (pH, conductivity, dissolved oxygen, and temperature) will be taken before, during, and after the development process. A Well Development Record will be prepared for each well. All water and sediment removed from the new wells should be containerized for appropriate disposal.

At the completion of monitoring well construction activities, each new well will be surveyed for horizontal and vertical control in accordance with USACE EM 1110-1-4000 protocol . The elevation of the inner well casing (at a designated marked point on the rim) and the ground surface at each new location will be established by a certified state surveyor. Control checks will be made to several existing wells. The horizontal well location will also be established relative to the existing state plane coordinate system. Vertical measurements will be made to the nearest 3 mm (0.01 ft), and horizontal measurements will be determined to the nearest 30 cm (1 ft). The identification, coordinates, and elevations of the new wells will be plotted on maps to show their location with references to existing wells and other site features.

2.2.16 Ground-Water Monitoring

Ground water at the St. Louis Sites may be monitored for piezometric head or sampled for a variety of analyses.

2.2.16.1 Ground-Water Sampling and Analyses

Ground-water samples acquired from ground-water monitoring wells may be analyzed for the radiological, metal, and chemical analytes using the methods and detection limits specified in the QAPP (Section 3.0). Analyses may be completed on filtered (0.45 µm) and/or unfiltered samples from each sampled location. The filtration of ground-water samples should be completed in the field prior to preservation in accordance to USACE protocol (Appendix E, EM-200-1-3). Off-site laboratory analyses of the ground-water samples should be provided at the confirmatory level of documentation. The analytical protocol used for all sampling events will follow Appendix C of USACE EM 200-1-3 and the QAPP.

DQOs will be developed to determine the required analyte list and sampling interval for ground water monitoring well sampling. These DQOs will need to be designed in a manner such that they remain valid for the overall ground-water sampling goals at the SLS, while working within fiscal constraints for the sites. Parameter or analyte selection will normally be limited to ROD-specified COCs. The COC concept develops from a risk-assessment and resolves the best analytes to monitor. The parameters for SLDS have been established in the SLDS' ROD. The North County Sites' parameters, for the short term, will include soil contaminants of potential concern (COPC) and some added analytes to assure protectiveness. The parameter selection should consider non-detects or detection levels below background, as applicable, and historical data of each well.

Ground-water sampling and sample analysis tasks will follow Appendix C and Appendix D of EM 200-1-3 (USACE, 1994c). The collection of ground-water samples from monitoring wells will be accomplished in three general steps: well purging, measurement of field parameters, and ground-water sample collection. If a non-aqueous phase liquid (NAPL) is present or suspected in the well, collection of a ground-water sample may not be appropriate (per EM-200-1-3). Monitoring wells should be purged and sampled in order, based on areas known to be least contaminated to areas known to be the most contaminated. Ground-water levels in each well should be measured with an electronic water level indicator on a single day prior to any site ground-water purging and sampling activities. The measurement will be made to the nearest 3 mm (0.01 ft) from the marked top of the riser pipe of the well. This measurement procedure will be repeated at least two times to ensure an accurate measurement. The well should then be sounded to determine the depth to the bottom of the well. The measured depth should be compared to its constructed depth to determine the necessary water purge volume. The elevations of the Mississippi River water level stage at SLDS will also be acquired during the day of ground-water level measurements for this site.

Purging and sampling of monitoring wells may be accomplished using an electrical submersible, peristaltic bladder pump, or similar equipment. The inlet of the pump or surface pump tubing should be placed at the midpoint of the water column. This level may be adjusted for wells where the static water level is within the well screen.

Micro-purging (low-flow rates) techniques should be employed in all wells to minimize the volume of purge water and disturbance to the aquifer. The field parameters, pH, conductivity, temperature, dissolved oxygen, and turbidity will be monitored during micro-purging. The purge rate should be adjusted, as necessary, to avoid purging any well to dryness to prevent aeration and to equal the recharge of the saturated zone. After the purge rate has stabilized, field water quality parameters will be measured and recorded every half of the well volume. Purging will be considered complete when the field parameters stabilize after a minimum of 3 readings at 5-minute intervals as follows: pH within 0.2 standard units; temperature - within 0.5 degrees Centigrade (°C); and other parameters - within 5 percent. The anticipated purge volume for stabilization is at least two well volumes.

The collection of ground-water samples from a monitoring well will begin immediately after completion of purging. If a well is purged dry, a ground-water sample may be collected after 75 percent of ground-water level recovery, or 24 hours. The ground-water sample volume obtained initially will be used for laboratory testing. All ground-water samples will be transferred directly into laboratory sample containers (see Table 2-3) from the pump tubing.

Immediately after the collection of samples and completion of sample container label information, each container will be placed into an ice-filled cooler to ensure preservation in accordance to EM 200-1-3 protocol. Collected samples will be immediately submitted to the selected laboratory for analyses using proper handling, shipping, and chain-of-custody procedures (see Section 3.4).

Purging and sampling equipment will be decontaminated before use and between sampling locations/intervals to prevent the potential for cross-contamination of samples. Refer to the SSHP for applicable decontamination procedures.

Water generated from well purging activities and decontamination water from ground-water sampling activities will be containerized and analyzed for later handling and disposal as IDW.

2.2.16.2 Remote Ground-Water Level Monitoring

A specialized monitoring system may be installed in selected wells. A remote monitoring system allows real-time monitoring of the ground-water surface.

2.2.17 Well and Borehole Decommissioning

Wells and boreholes to be abandoned will be sealed and closed in accordance with the guidance provided in Table 2-5, USACE EM 1110-1-4000 requirements, and MDNR regulations. Attempts should be made to remove the casing and screen from each borehole during well decommissioning.

The four recognized backfills are High-solids Bentonitic Slurry-Grout, Bentoniticchips, Strength Grout, and native soil. Gravel is the preferred completion surface for new monitoring well installations. The surface completion of decommissioned wells and exploration holes should be equivalent to the surroundings surface. Base course and pavement may be appropriate. The upper two feet of decommissioned wells (but not monitoring well placements) and exploration holes may have a soil backfill for a growing medium. The backfills, other than soil, shall conform to the following mixes.

- **High-solids:** Bentonitic Slurry-Grout. Unaltered high solids, slurry of sodium bentonite, at least in the range of twenty to thirty (20%-30%) by weight solids Polymer additives may not be used.
- **Strength Grout:** 94 pounds of Type I Portland cement, 45 pounds of unaltered Bentonite, and 15 gallons of water. This grout has a considerable strength relative to soils but would only be used in locations with strength requirements, as directed by USACE.
- **Bentonitic Chips:** Unaltered Bentonitic chips tamped into the hole. The correct chip size shall be provided for the annular space being filled.
- **Native Soil**: Backfill for the upper two feet of the hole with a vegetative surface.

The proper grout mix will be placed under pressure into the borehole/well via a tremie pipe from total depth to 61 cm (2 ft) bgs. After 24 hours, the grout level will be checked for settlement and additional grout will be placed in the borehole as necessary. The drive-over manhole or protective steel casing and the surrounding cement collar at each well will be removed. The area of the former well should be filled either with gravel base (as necessary) and capped with asphalt or cement or native soil, depending on the surrounding surface material. The procedures and supplies used to decommission the two wells will be documented by a supervising scientist/engineer in accordance with USACE EM 1110-1-4000 (Chapter 3).

3.0 QUALITY ASSURANCE PROJECT PLAN (QAPP)

This portion of the SAG presents the QAPP for activities to be performed at the SLS. This QAPP provides the organization, objectives, functional activities and specific QA and QC activities associated with investigations and sampling activities at the SLS. All QA/QC procedures will be performed in accordance with applicable professional technical standards, EPA requirements, government regulations and guidelines, and specific project goals and requirements. This QAPP has been prepared in accordance with EPA and USACE guidance documents, *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* (EPA, 1991), *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA, 1994a), and *Requirements for the Preparation of Sampling and Analysis Plans* (USACE, 1994c).

3.1 Project Organization and Responsibilities

The overall organizational chart shown on Figure 3-1 outlines the management structure that will be used to implement the St. Louis sampling and analysis activities. The responsibilities of key positions are described in this section. These roles may be filled by a combination of USACE staff, contractor staff, and subcontractors. The assignment of personnel to each position will be based on a combination of (1) experience in the type of work to be performed, (2) experience working with USACE personnel and procedures, (3) a demonstrated commitment to high quality and timely job performance, and (4) staff availability.

3.1.1 USACE Task/Technical Lead

The USACE Task/Technical Lead for the St. Louis District has overall responsibility for the SLS and assures that the requirements of the SAG and WD are implemented by USACE and contractor personnel.

3.1.2 Project Manager

The St. Louis Project Manager has direct responsibility for implementing the SAG, QAPP, and activity-specific WDs (see Section 1.8) including all phases of work element development, field activities, data management, and report preparation. This individual will also provide overall management of the project, and serve as the technical lead and point of contact with the USACE Task/Technical Lead. These activities will involve coordinating all personnel working on the project, interfacing with USACE personnel, and tracking project budgets and schedules. The Project Manager will also develop, monitor, and fill project staffing needs, delegate specific responsibilities to project team members, and coordinate with administrative staff to maintain a coordinated and timely flow of all project activities.

3.1.3 Quality Assurance (QA)/Quality Control (QC) Officer

The QA/QC Officer is responsible for project QA/QC in accordance with the requirements of the QAPP, WDs, and appropriate management guidance. This individual, in coordination with the Chemical Quality Control (CQC) Representative, will be responsible for participating in the following: project field activity readiness reviews; approving variances during field activities before work continues; approving, evaluating, and documenting the

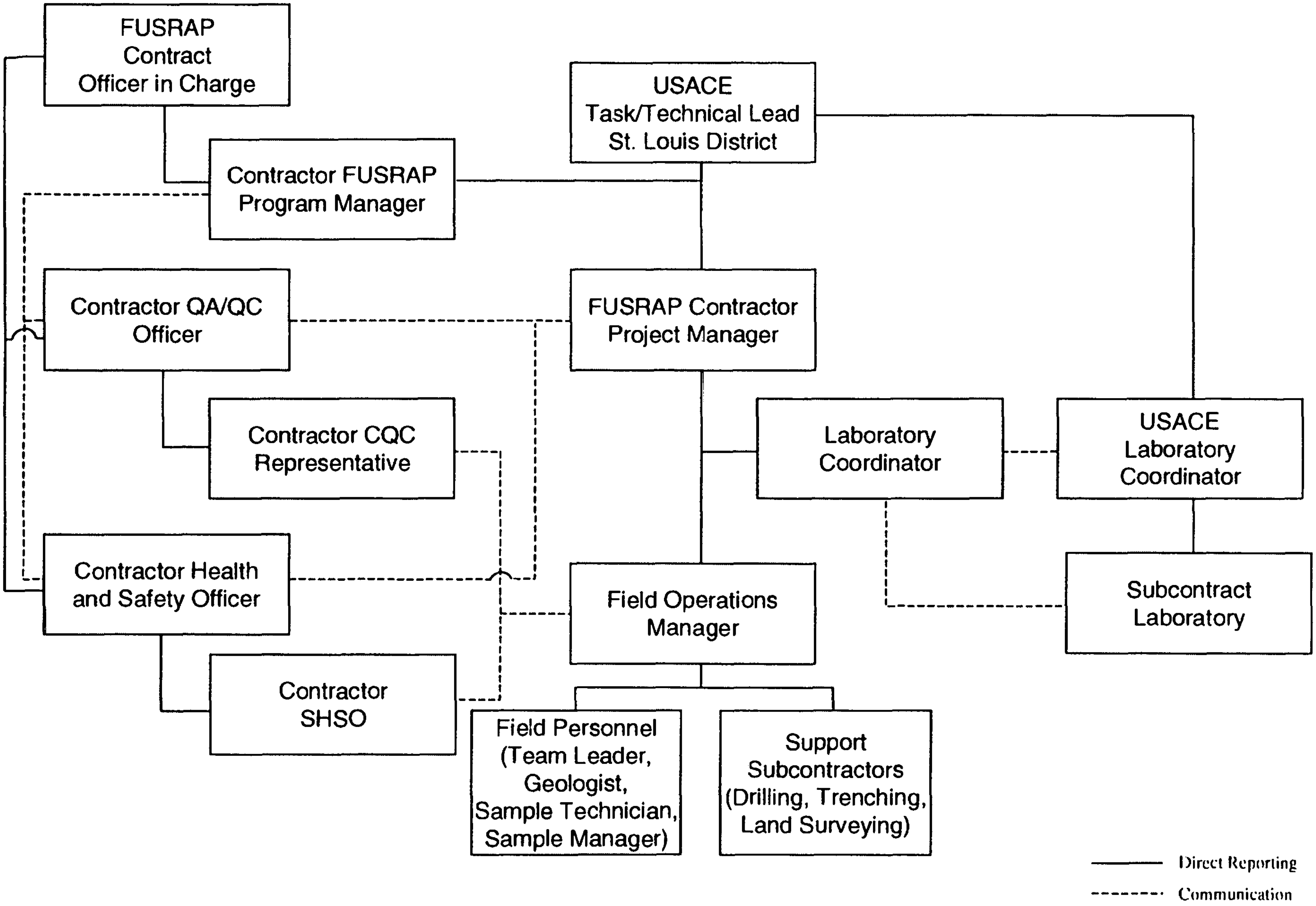


Figure 3-1. St. Louis FUSRAP Sites Organizational Chart

disposition of Nonconformance Reports (NCRs) or other corrective action documentation; overseeing and approving any required project training; and designing audit/surveillances followed by supervision of these activities. The QA/QC Officer reports directly to the contractor's responsible Corporate Officer and indirectly to the St. Louis Project Manager.

3.1.4 Chemical Quality Control (CQC) Representative

The CQC Representative is responsible for implementation and documentation of all project QA/QC protocols during field activities. In this capacity the CQC Representative will direct and implement the various components of the contractor CQC program as defined in USACE Manual EM200-1-3. This will include but not be limited to: documentation of QAPP instructions to field personnel; oversight of field sampling and analytical activities; documentation of field QC activities; and completion of Daily Quality Control Reports (DQCRs). The CQC Representative reports directly to the QA/QC Officer, but will also inform the Project Manager of all information and decisions reported.

3.1.5 USACE Laboratory Coordinator

The USACE Laboratory Coordinator oversees the USACE analytical subcontract laboratory and the USACE QA laboratory.

3.1.5.1 USACE Chemical QA Laboratory

The USACE QA Laboratory for analytical chemistry is the USACE HTRW Center of Excellence (CX), Omaha, NE. The point of contact is Douglas Taggart, 402-444-4300. The shipping address is:

Attn: CECM-QAL
420 South 18th Street
Omaha, NE 68102

3.1.5.2 USACE Radiological QA Laboratory

QA splits for radiological constituents will be performed by an off-site laboratory approved for use by USACE.

3.1.6 Contractor Health and Safety Officer

The Contractor Health and Safety Officer is responsible for ensuring that health and safety procedures designed to protect personnel are maintained throughout the field activities. This will be accomplished by strict adherence to the applicable SSHP, which is prepared as a separate document for each project. This individual, in conjunction with the Site Safety and Health Officer (SSHO), will have the authority to halt fieldwork if health or safety issues arise that are not immediately resolvable in accordance with the applicable SSHP. The SSHO reports directly to the contractor's responsible Corporate Officer and indirectly to the FUSRAP Project Manager.

3.1.7 Laboratory Field Coordinator

The Laboratory Field Coordinator is responsible for coordination of sample shipment to the analytical laboratory(ies), and requests for chemical and radiochemical analysis and reporting by the subcontract laboratory(ies), in accordance with the requirements defined in the activity-specific WD. This individual will also coordinate the shipment of samples to the USACE QA laboratory(ies), which has been designated as the government QA laboratory(ies) for the project. This individual will be responsible for obtaining required sample containers from the laboratory(ies) for use during field sample collection; resolving questions that the laboratory may have regarding QAPP requirements and deliverables; and coordinating data reduction, validation, and documentation activities related to sample data package deliverables received from the laboratories. The Laboratory Field Coordinator reports directly to the St. Louis Project Manager.

3.1.8 Field Operations Manager

The Field Operations Manager (FOM) is responsible for implementing all field activities in accordance with the SAG, this QAPP, and the activity-specific WD. This individual is responsible for the following: ensuring proper technical performance of drilling operations and field sampling activities, adherence to required sample custody and other related QA/QC field procedures, coordination of field personnel activities, management of investigative-derived wastes, checks of all field documentation, and preparation of Field Change Orders (FCOs), if required. The FOM reports directly to the St. Louis Project Manager except in regard to QA/QC matters that are reported directly to the QA/QC Officer.

3.1.9 Field Personnel

In addition to the FOM, other field personnel participating in implementation of field activities are anticipated to be site geologists/soil scientists, sampling technicians, and the sample manager. These individuals, in coordination with field subcontractor personnel, will be responsible for performance of drilling operations, collection of soil, ground water, surface water, radiation monitoring, and preparation samples. Field logbooks and other required documentation will be employed in the performance of these activities. These individuals will be responsible for performing all field activities in accordance with the SAG, this QAPP, and the activity-specific WD. Field personnel report directly to the FOM.

3.1.10 Subcontractor Field Personnel

Subcontractor field personnel, under the supervision of the FOM, will be responsible for performing their specific scopes of work that have been derived from the applicable SAG. These individuals will be required to review applicable sections of the SAG, QAPP, activity-specific WD, and the entire SSHP prior to field mobilization. All subcontractor field personnel report directly to the FOM who will be responsible for ensuring that all subcontractor activities comply with project requirements.

3.1.11 Subcontractor Laboratory Support

Primary radiological analytical laboratory support specific to these investigations will be obtained from the HISS on-site radiological laboratory. Off-site laboratory designation may be changed as necessary for specific activities, but will typically be documented in the activity-specific WD. Chemical and radiochemical laboratory support for these investigations will be designated to these subcontractors based on their capacities and capabilities. These selected subcontract laboratories will be validated by the USACE HTRW CX, Omaha, Nebraska. Relevant QA Manuals, laboratory qualification statements, certifications, and license documentation will be made available upon request. Geotechnical laboratory support will be designated to a separate subcontractor and will follow the same concept as identified above.

Organization charts outlining the key laboratory personnel and organization should be identified in their QA Plans. The responsibilities of key personnel are described in the following paragraphs. The assignment of personnel to each position will be based on a combination of (1) experience in the type of work being performed, (2) experience working with USACE personnel and procedures, and (3) a demonstrated commitment to high quality and timely job performance.

Prior to commencement of field activities for each project, the contractor should send a complete copy of this SAG (including this QAPP) and the activity-specific WD to all subcontracted laboratories.

3.1.11.1 Laboratory Quality Assurance/Quality Control (QA/QC) Manager

The subcontractor Laboratory QA/QC Manager is responsible for the laboratory QA/QC in accordance with the requirements of this QAPP in conjunction with the established laboratory QA Program. In coordination with the USACE Laboratory Coordinator and the Contractor Laboratory Coordinator, this individual will be responsible for documenting that samples received by the laboratory are analyzed in accordance with required methodologies, that instrument calibration is performed properly and documented, that field and internal laboratory QC samples are analyzed and documented, and that all analytical results for both field and QC samples are reported to USACE and the contractor in the format required in the laboratory scope of work, this QAPP, and the activity-specific WD. This individual is also responsible for processing laboratory NCRs in a timely manner and for implementing corrective action recommendations and requirements. The Subcontractor Laboratory QA/QC Manager reports directly to the USACE Laboratory Coordinator and indirectly to the contractor Laboratory Field Coordinator for issues related to this project.

3.1.11.2 Laboratory Project Manager

The responsibilities of each laboratory's Project Manager include the following: initiation and maintenance of contact with USACE and the contractor on individual job tasks; preparation of all laboratory-associated work plans, schedules, and manpower allocations; initiation of all laboratory-associated procurement for the project; provision of day-to-day direction of the laboratory project team including analytical department managers, supervisors, QA personnel, and data management personnel; coordination of all laboratory related financial and contractual aspects of the project; provision of formatting and technical review for all laboratory reports; provision of day-to-day communication with USACE and the contractor; provision of final review and approval on all laboratory analytical reports to USACE and the contractor; and response to all post project inquires.

3.1.11.3 Laboratory Manager

The responsibilities of the Laboratory Manager for each laboratory include the following: coordination of all analytical production activities conducted within the analytical departments; working with the Laboratory Project Manager to ensure all project objectives are met; provision of guidance to analytical department managers; and facilitation of transfer of data produced by the analytical departments to the report preparation and review staff for final delivery to the client.

3.1.11.4 Laboratory Section Heads, Department Managers, and Technical Leads

The responsibilities of each laboratory section or department include the following: coordination of all analytical functions related to specific analytical areas; provision of technical information to and oversight of all analysis being performed; review and approval of all analytical results produced by their specific analytical area of expertise; and maintenance of all analytical records and information pertaining to the analysis being performed.

3.2 Data Quality Objectives

The overall objective is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting, which will provide information for site evaluation and assessment leading to and including remediation. Data must be technically sound and legally defensible. Procedures for sampling, chain-of-custody, laboratory instrument calibration, laboratory analysis, reporting of data, internal QC, audits, preventive maintenance of field equipment, and corrective action are described in other sections of this QAPP. The purpose of this section is to address the objectives for data accuracy, precision, completeness, representativeness, and comparability. The WD is used to identify specific task objectives as they relate to site action levels and remediation. The activity-specific WD for each St. Louis task or activity will also provide the details, in tabular form, of the analytical parameters, methods, and quantitation levels.

DQOs are qualitative and quantitative statements that specify the quality of data required to support decisions made during investigation activities, and are based on the end uses of the data being collected. Detailed, site-specific DQOs are provided in the activity-specific WD.

3.2.1 Project Objectives

General objectives are as follows:

- To provide data of sufficient quality and quantity to support ongoing remedial efforts, meet the requirements of the EMG, supplement the Feasibility Study (FS), and develop a ROD for the site.
- To provide data of sufficient quality to meet applicable State of Missouri and federal concerns (e.g., reporting requirements).

- To ensure samples are collected using approved techniques and are representative of existing site conditions.

- To specify QA/QC procedures for both field and laboratory methodology to meet the USACE and other applicable guidance document requirements.

3.2.2 Quality Assurance Objectives for Measurement Data

An analytical DQO summary for these investigations is presented in Tables 3-1 and 3-2. Any deviations or exceptions will be detailed in the activity-specific WD. All QC parameters that are stated in the specific SW-846 methods (i.e., percent recoveries) should be adhered to for each chemical listed.

Table 3-1. Soil/Sediment DQO[1] Summary for St. Louis FUSRAP Investigations

Data Use	Sample Type	Analytical Method	Precision Field Dups	(RPD)[2] Lab Dups	Accuracy (LCS[3]/MS)	Completeness[4]
Screening for sample site selection	Discrete	FID/PID Volatile Organics	+/- comparison	NA	+/- 0.1 ppm	95%
		Radiological monitoring	+/- cpm[5]	NA	NA	95%
Confirmation of contamination extent and risk assessment, and determination of waste characteristics	Discrete	SW-8260B Volatile Organics	<50 RPD	<35 RPD	50-150% recovery	90%
	Discrete or Composite	SW-8270C Semivolatile Organics	<50 RPD	<35 RPD	30-140% recovery	90%
		SW-8081A/ 8082 Pesticides/PCBs	<50 RPD	<35 RPD	35-135% recovery	90%
		SW-6010A/6020/ 7000 Metals	<50 RPD	<35 RPD	75-125% recovery	90%
		Radiochemical various	<50 RPD	<35 RPD	75-125% recovery	90%
		Other Waste Characteristics[6]	NA RPD	<40	50-150% recovery	90%
		Physical Testing[7]	NA	<40 RPD	NA	90%

[1] These DQOs will also apply to waste, IDW, air filter, soil gas absorbent, and other solid sample media.

[2] RPD = Relative Percent Difference, at values within five times the reporting level comparison is acceptable when values are plus or minus three times the reporting level.

[3] Goals include having 90 percent of the measurements within the recovery and RPD criteria for laboratory control sample (LCS) and duplicate samples.

[4] Criteria samples will be identified in the SAP, where 100 percent completeness is required.

[5] cpm = counts per minute

[6] See Table 3-4 for analytical methods.

[7] See Table 2-4 for analytical methods.

Table 3-2. Water and Field QC Investigative DQO Summary for St. Louis FUSRAP Investigations

Data Use	Sample Type	Analytical Method	Precision Field Dups	(RPD)[1] Lab Dups	Accuracy (LCS[2]/MS)	Completeness[3]
Screening for sample site selection	Discrete	FID/PID Volatile Organics	NA	NA	+/- 0.1 ppm	95%
Determination of basic water characteristics	Discrete	EPA-120.1 Conductivity	<10 RPD	NA	+/- 10 Φmhos/cm	95%
		EPA-150.1 pH	<10 RPD	NA	+/- 0.1 s.u.	95%
		EPA-170.1 Temperature	<10 RPD	NA	NA	95%
		EPA-180.1 Turbidity	<10 RPD	NA	+/- 2 NTU	95%
Confirmation of contamination extent and risk assessment	Discrete	SW-8260B Volatile Organics	<30 RPD	<20 RPD	50-150% recovery	90%
	Discrete or Composite	SW-8270C Semivolatile Organics	<30 RPD	<20 RPD	30-140% recovery	90%
		SW-8081A/ 8082 Pesticides/PCBs	<30 RPD	<20 RPD	35-135% recovery	90%
		SW-6010A/6020/ 7000 Metals	<30 RPD	<20 RPD	75-125% recovery	90%
		Anions and other water quality parameters various	<30 RPD	<20 RPD	75-125% recovery	90%
		Radiochemical various	<30 RPD	<20 RPD	75-125% recovery	90%

[1] RPD = Relative Percent Difference; at values within five times the reporting level comparison is acceptable if values are plus or minus twice the reporting level.

[2] Goals include having 90 percent of the measurements within the recovery and RPD criteria for LCS and duplicate samples.

[3] Critical samples will be identified in the SAP, where 100 percent completeness is required.

Laboratories are required to comply with all methods as written. Laboratories selected may be required to submit all lab method standard operating procedures (SOPs) and references, and the actual method detection limits to be achieved in all analyses to the contractor and USACE.

In accordance with EPA guidance (EPA, 1987; EPA, 1993a), a combination of Screening Level and Definitive Level data may be required for each project. Definitive data represent data generated under laboratory conditions using EPA-approved procedures. Data of this type, both qualitative and quantitative, are used for determination of source, extent, or characterization and to support evaluation of remedial technologies and preliminary assessment memorandum.

3.2.2.1 Level of Quality Control Effort

To assess whether QA objectives have been achieved, analyses of specific field and laboratory QC samples will be required. These QC samples include field trip blanks, field duplicates, laboratory method blanks, laboratory control samples, laboratory duplicates, rinsate blanks, source water blanks, and matrix spike/matrix spike duplicate (MS/MSD) samples.

Trip blanks, rinsate blanks, and source water blanks will be submitted for analysis along with field duplicate samples to provide a means to assess the quality of the data resulting from the field sampling program. Trip blanks (employed for VOC analysis) are used to assess the potential for contamination of samples due to contaminant migration during sample shipment and storage. Trip blanks for thermoluminescent dosimeters (TLDs) measure the dose accumulated in transit to the laboratory. Rinsate blanks are used to assess the effectiveness of field decontamination processes in conjunction with source water blanks of the site potable water source used for decontamination. Criteria and evaluation of blank determinations, that are expected to apply to St. Louis Sites, are found in Table 3-3 and are discussed in Section 3.7.3. Field duplicate samples are analyzed to determine sample heterogeneity and sampling methodology reproducibility.

Field QA split samples will be collected as co-located or homogenized replicates of field QA samples and distributed to the government's identified QA laboratory for analysis. Split samples will be implemented by USACE for detection of problems with field sampling, documentation, packaging, or shipping. They also provide an independent referee laboratory analysis, allowing the project to check the primary analytical result sensitivity, accuracy, and precision. With the exception of screening samples, QA split samples should be collected and analyzed at a frequency of approximately once every twenty samples (5 percent), or a minimum of one split sample per matrix sampled.

Laboratory method blanks and laboratory control samples are employed to determine the accuracy and precision of the analytical method implemented by the laboratory. MS's provide information about the effect of the sample matrix on the measurement methodology. Laboratory sample duplicates and MS and MSDs assist in determining the analytical reproducibility and precision of the analysis for the analytes of interest.

The general level of QC effort should be at least one field duplicate for every 20 investigative samples and at least one per matrix if there are less than 20 samples collected for a given matrix. One VOC analysis trip blank consisting of analyte-free water will be included along with each shipment of VOC water samples. Contractors should consolidate coolers as much as practical to limit the required number of trip blanks sent to the laboratories. In all cases, trip blanks should never exceed more than one per day. Unless otherwise directed by the District Chemist, one rinsate blank shall be taken for an entire sampling event. Other required QC samples will be defined in the activity-specific WDs.

MS/MSD samples are investigative samples. Soil MS/MSD samples require no extra volume for SVOCs, metals, or radionuclides; however, soil VOC samples will require additional samples to be collected for these purposes. Aqueous MS/MSD samples must be collected at triple the volume for SVOC, pesticide/PCB, and radionuclide parameters. One MS/MSD sample should be designated in the field and collected for at least every 20 investigative samples per sample matrix (i.e., ground water, soil).

The goal is to provide a level of QC effort in conformance with the protocols of the EPA Contract Laboratory Program (CLP) for Routine Analytical Services (RAS) parameters. The level of QC effort for testing and analysis of parameters beyond the scope of the CLP protocols will conform to accepted methods, such as EPA SW-846 protocols (EPA, 1993b), ASTM protocols, and National Institute for Occupational Safety and Health (NIOSH) protocols.

The QC effort for in-field measurements, including temperature, conductivity, pH, organic vapor concentrations, and radiation levels, will include daily calibration of instruments using traceable standards and documented instrument manufacturer procedures. Daily calibration will also be done on all radiation detection field meters. Field instruments and their methods of calibration are discussed further in Section 3.6 of this QAPP.

3.2.2.2 Accuracy, Precision, and Sensitivity

The fundamental QA objectives for accuracy, precision, and sensitivity of laboratory analytical data are the QC acceptance criteria of the analytical protocols. The accuracy and precision required for each project's analytical parameters are incorporated in Tables 3-1 and 3-2 and will be consistent with the analytical protocols. Typical Practical Quantitation Limits (PQLs) required for project analyses are provided in Tables 3-3 and 3-4. Specifics will be tailored for each investigation and will be included in the activity-specific WD.

Table 3-3. Analytical/Methods, Parameters, and Project Quantitation Limits for the St. Louis FUSRAP Sites

	Analytical Methods		Project Quantitation Levels[a]	
Parameters	**Water**	**Soil/Sediment**	**Water**	**Soil/Sediment**
Volatile Organic Compounds (VOCs):	SW 846 5030/8260B	SW-846-5035/8260B	(µg/L)	(µg/kg)
Chloromethane			10	10
Bromomethane			10	10
Vinyl Chloride			2	2
Chloroethane			10	10
Methylene Chloride (dichloromethane)			5	5
Acetone			10	10
Carbon disulfide			5	5
1,1-Dichloroethene			5	5
1,1-Dichloroethane			5	5
1,2-Dichloroethene (total)			5	5
Chloroform			5	5
1,2-Dichloroethane			5	5
2-Butanone			10	10
Carbon tetrachloride			5	5
Bromodichloromethane			5	5
1,2-Dichloropropane			5	5
cis-1,3-Dichloropropene			5	5
Trichloroethene (TCE)			5	5
Dibromochloromethane			5	5
1,1,2-Trichloroethane			5	5
Benzene			5	5
trans-1,3-Dichloropropene			5	5

Table 3-3. Analytical/Methods, Parameters, and Project Quantitation Limits for the St. Louis FUSRAP Sites (Cont'd)

Parameters	Analytical Methods		Project Quantitation Levels[a]	
	Water	Soil/Sediment	Water	Soil/Sediment
1,1,-Trichloroethane	SW-846-5030/8260B	SW-846-5035/8260B	5	5
Tribromomethane			5	5
4-Methyl-2-pentanone			10	10
2-Hexanone			10	10
Tetrachloroethene			5	5
Toluene			5	5
1,1,2,2-Tetrachloroethane			5	5
Chlorobenzene			5	5
Ethylbenzene			5	5
Styrene			5	5
Xylenes (total)			5	5
Semivolatile Organic Compounds (SVOCs):	SW-846-3520/8270C[b]	SW-846-3550/8270C[b]	(µg/L)	(µg/kg)
Phenol			10	330
bis(2-Chloroethyl) ether			10	330
2-Chlorophenol			10	330
1,3-Dichlorobenzene			10	330
1,4-Dichlorobenzene			10	330
1,2-Dichlorobenzene			10	330
2-Methylphenol			10	330
2,2'- oxybis(1-Chloropropane)			10	330
4-Methylphenol			10	330
N-nitroso-di-n-dipropylamine			10	330
Hexachloroethane			10	330
Nitrobenzene			10	330
Isophorone			10	330
2-Nitrophenol			10	330
2,4-Dimethylphenol			10	330
bis(2-chloroethoxy) methane			10	330
2,4-Dichlorophenol			10	330
1,2,4-Trichlorobenzene			10	330
Naphthalene			10	330
4-Chloroaniline			10	330
Hexachlorobutadiene			10	330
4-Chloro-3-methylphenol			10	330
2-Methylnaphthalene			10	330
Hexachlorocyclopentadiene			10	330
2,4,6-Trichlorophenol			10	330
2,4,5-Trichlorophenol			25	800
2-Chloronaphthalene			10	330
2-Nitroaniline			25	800
Dimethylphthalate			10	330
Acenaphthylene			10	330
2,6-Dinitrotoluene			10	330
3-Nitroaniline			25	800
Acenaphthene			10	330
2,4-Dinitrophenol			25	800
4-Nitrophenol			25	800
Dibenzofuran			10	330
2,4-Dinitrotoluene			10	330
Diethylphthalate			10	330

Table 3-3. Analytical/Methods, Parameters, and Project Quantitation Limits for the St. Louis FUSRAP Sites (Cont'd)

Parameters	Analytical Methods		Project Quantitation Levels[a]	
	Water	Soil/Sediment	Water	Soil/Sediment
4-Chlorophenyl-phenyl ether	SW-846-3520/8270C[b]	SW-846-3520/8270C[b]	10	330
Fluorene			10	330
4-Nitroaniline			25	800
4,6-Dinitro-2-methylphenol			25	800
N-nitrosodiphenylamine			10	330
4-bromophenyl-phenylether			10	330
Hexachlorobenzene			10	330
Pentachlorophenol			25	800
Phenanthrene			10	330
Anthracene			10	330
Carbazole			10	330
Di-n-butylphthalate			10	330
Fluoranthene			10	330
Pyrene			10	330
Butylbenzylphthalate			10	330
3,3'-Dichlorobenzidine			10	330
Benzo(a)anthracene			10	330
Chrysene			10	330
bis(2-Ethylhexyl)phthalate			10	330
Di-n-octylphthalate			10	330
Benzo(b)fluoranthene			10	330
Benzo(k)fluoranthene			10	330
Benzo(a)pyrene			10	330
Indeno(1,2,3-cd)pyrene			10	330
Dibenzo(a,h)anthracene			10	330
Benzo(g,h,i)perylene			10	330
Pesticides/PCBs:	SW-846-3520 8080	SW-846-3550 8080	(µg/L)	(µg/kg)
alpha-BHC			0.05	1.7
beta-BHC			0.05	1.7
delta-BHC			0.05	1.7
Gamma-BHC (Lindane)			0.05	1.7
Heptachlor			0.05	1.7
Aldrin			0.05	1.7
Heptachlor epoxide			0.05	1.7
Endosulfan I			0.05	1.7
Dieldrin			0.1	3.3
4,4'-DDE			0.1	3.3
Endrin			0.1	3.3
Endosulfan II			0.1	3.3
4,4'-DDD			0.1	3.3
Endosulfan sulfate			0.1	3.3
4,4'-DDT			0.1	3.3
Methoxychlor			0.50	17
Endrin ketone			0.1	3.3
Endrin aldehyde			0.1	3.3
alpha-Chlordane			0.05	1.7
Gamma-Chlordane			0.05	1.7
Toxaphene			5.0	170
Arochlor-1016			0.5	33
Arochlor-1221			0.5	67

Table 3-3. Analytical/Methods, Parameters, and Project Quantitation Limits for the St. Louis FUSRAP Sites (Cont'd)

	Analytical Methods		Project Quantitation Levels[a]	
Parameters	**Water**	**Soil/Sediment**	**Water**	**Soil/Sediment**
Arochlor-1232	SW-846-3520 8080	SW-846-3550 8080	0.5	33
Arochlor-1242			0.5	33
Arochlor-1248			0.5	33
Arochlor-1254			0.5	33
Arochlor-1260			0.5	33
Herbicides	SW-846-8150	SW-846-8150	(μg/L)	(μg/kg)
2,4,D			1	20
Dalapon			2	40
2,4,DB			1	20
Dicamba			0.2	4
Dichlorprop			1	20
Dinoseb			0.2	4
2-methyl-4-chlorophenoxy acetic acid (MCPA)			1	20
2-(2-methyl-4-chlorophenoxy) propionic acid (MCPP)			1	20
2,4,5-TP (Silvex)			0.5	10
2,4,5-T			0.5	10
Metals (Target Analyte List):	SW-846-3010A/6010B, 6020, or 7000 series[b]	SW-846-3050A/6010B, 6020, or 7000 series[b]	(μg/L)	(mg/kg)[c]
Aluminum			50	5
Antimony			5	0.5
Arsenic *			5	0.5
Barium			5	0.5
Beryllium			1	0.1
Cadmium*			1	0.1
Calcium			50	5
Chromium			5	0.5
Cobalt			5	0.5
Copper			5	0.5
Iron			10	1.0
Lead			3	0.3
Magnesium			50	5
Manganese			5	0.5
Mercury (CVAA)	SW-846-7470	SW-846-7471	0.2	0.1
Nickel	SW-846-6020, 3010A/6010B, or 7000 series[b]	SW-846-6020, or 3050A/6010B, 7000 series[b]	10	1.0
Potassium			50	5
Selenium			5	0.5
Silver			5	0.5
Sodium			50	5
Thallium			2	0.2
Vanadium			10	1.0
Zinc			5	0.5
Additional Elements				
Boron	SW-846-6020, 3010A/6010B, or 7000 series[b]	SW-846-6020, or 3050A/6010B, 7000 series[b]	50	5
Molybdenum			50	5
Lithium			50	5
Strontium			5	0.5
Titanium			50	5
Uranium			5	0.5

Table 3-3. Analytical/Methods, Parameters, and Project Quantitation Limits for the St. Louis FUSRAP Sites (Cont'd)

	Analytical Methods		Project Quantitation Levels[a]	
Parameters	**Water**	**Soil/Sediment**	**Water**	**Soil/Sediment**
Cyanide	SW-846-9010	SW-846-9011/9010	(mg/L) 10	(mg/kg) 0.5
Anions: **(dissolved or leachable)**			(mg/L)	(mg/kg)
Alkalinity (carbonate & bicarbonate)	EPA 310.1		NA	-
Nitrate-Nitrite as N	EPA 353.2		0.2	-
Ammonia (NH_3) as N	EPA 350.1		0.1	-
Sulfide	EPA 376.1		1.0	-
Sulfate	SW-846 - 9056		5.0	-
Chloride	SW-846 - 9056		1.0	-
Fluoride	SW-846 - 9056		0.1	-
Phosphate	EPA 365.4		0.1	-
Miscellaneous:			(mg/L)	(mg/kg)
pH	SW-846-9045	SW-846-9045	NA	NA
Paint Filter Test	-	SW-846-9095	-	0.1%
Cyanide Reactivity	-	SW-846-Chap. 7	-	2.5
Sulfide Reactivity	-	SW-846-Chap. 7	-	25
Ignitability	-	SW-846-Chap. 7	-	NA
Total Organic Carbon	SW-846-9060	-	1	-
Total Dissolved Solids	EPA 160.1[d]	-	10	-
Total Suspended Solids	EPA 160.2[d]	-	4	-
Radiochemical Parameters*			pCi/L	pCi/g
Gamma Spectral Scan		Gamma Spec.[e]	NA	NA
Iso-Uranium 234, 235, 238	Alpha Spec.[e]	Gamma Spec/ Alpha Spec.[e]	1 each	1 each
Iso-Thorium 228, 230, 232	Alpha Spec.[e]	Alpha Spec.[e, f]	1 each	1 each
Radium 226, 228	Alpha Spec	Gamma Spec.[e] Alpha Spec.	1 each	1 each
Protactinium 231	Gamma Spec.[e]	Gamma Spec.[e]		3
Actinium 227		Gamma Spec./ Alpha Spec.[e]		1

[a] These are expected quantitation limits based on reagent-grade water or a purified solid matrix. Actual quantitation limits may be higher depending upon the nature of the sample matrix. The limit reported on final laboratory reports will take into account the actual sample volume or weight, percent solids (where applicable), and the dilution factor, if any. The quantitation limits for additional analytes to this list may vary, depending upon the results of laboratory studies. All solids will be reported on a dry-weight basis, with the associated sample percent moisture reported separately.

[b] *Test Methods for Evaluating Solid Waste*, U.S. Environmental Protection Agency (EPA), SW-846 Third Edition.

[c] Estimated detection limits for metals in soil are based on a 2-gram sample diluted to 200 mL.

[d] *Methods for Chemical Analysis of Water and Wastes*, U.S. EPA-600/4-79-020.

[e] Laboratory-specific procedures, which are consistent with U.S. Department of Energy Environmental Measurements Laboratory (EML) Procedure Manual (HASL-300), will be submitted for the project files.

[f] If the sample contains greater than 500 pCi/g of Th-230, based on gamma spectroscopy scan, then alpha spectroscopy will not be conducted and the results will be quantified by gamma spectroscopy.

* SLDS COCs (ROD, 1998)

Table 3-4. Analytical/Methods, Parameters, and Project Quantitation Limits for St. Louis FUSRAP Sites – Waste Characteristics

	Analytical Methods	Project Quantitation Levels[a]
Parameters	**Soil/Sediment Waste**	
Volatile Organic Compounds (VOCs) (TCLP Analyte List)	SW-846-1311 (zero headspace ext.) SW-846-5030/8260B[b]	Leachate (µg/L)[c]
Vinyl chloride		20[d]
1,1-Dichloroethene		7
Chloroform		60
1,2-Dichloroethane		5
2-Butanone		2000
Carbon tetrachloride		5
Trichloroethene		5
Benzene		5
Tetrachloroethene		7
Chlorobenzene		1000
Semivolatile Organic Compounds (SVOCs) (TCLP Analyte List)	SW-846-1311 (extraction) SW-846-3520/8270C[b]	Leachate (µg/L)[c]
1,4-Dichlorobenzene		75
2-Methylphenol (o-cresol)		2000
3-Methylphenol (m-cresol)		2000
4-Methylphenol (p-cresol)		2000
Hexachloroethane		30
Nitrobenzene		20
Hexachlorobutadiene		50[d]
2,4,6-Trichlorophenol		20
2,4,5-Trichlorophenol		4000
2,4-Dinitrotoluene		13[d]
Hexachlorobenzene		13[d]
Pentachlorophenol		1000
Pyridine		500[d]
Pesticides (TCLP Analyte List)	SW-846-1311 (extraction) SW-846-3520/8081A[b]	Leachate (µg/L)
gamma-BHC (Lindane)		4.0
Heptachlor		0.08
Heptachlor epoxide		0.08
Endrin		0.2
Methoxychlor		100
Chlordane (total)		0.3
Toxaphene		5.0
Herbicide Compounds (TCLP Analyte List)	SW-846-1311 (extraction) SW-846-8151[b]	Leachate (µg/L)
2,4-D		100
2,4,5-TP (silvex)		10

Table 3-4. Analytical/Methods, Parameters, and Project Quantitation Limits for St. Louis FUSRAP Sites – Waste Characteristics (Cont'd)

Parameters	Analytical Methods	Project Quantitation Levels[a]
	Soil/Sediment Waste	
Metals **(TCLP Analyte List)**	SW-846-1311 (extraction) 3010A/6010B, 6020, or 7000 series[b]	Leachate (µg/L)
Arsenic		50
Barium		100
Cadmium		10
Chromium		50
Copper		50
Lead		30
Mercury (CVAA)	SW-846-7470[b]	20
Selenium	SW-846-1311 (extraction) 3010A/6010B, 6020, or 7000 series[b]	10
Silver		50
Zinc		50
PCB Total	SW-846-8080[b]	0.5 mg/kg
Waste Characteristics		
pH/Corrosivity	SW-846-9045[b]	NA
Paint Filter Liquid Test (free liquids)	SW-846-9095[b]	0.1%
Cyanide Reactivity	SW-846-Chapter 7[b]	2.5 mg/kg
Sulfide Reactivity	SW-846-Chapter 7[b]	5.0 mg/kg
Ignitablity	SW-846-Chapter 7[b]	NA
Total Petroleum Hydrocarbons (TPH)	SW-846-9073[b]	10 mg/kg
Total Organic Halides (TOX)	SW-846-9020[b]	5 mg/kg

[a] These are expected quantitation limits based on reagent-grade water or a purified solid matrix. Actual quantitation limits may be higher depending upon the nature of the sample matrix. The limit reported on final laboratory reports will take into account the actual sample volume or weight, percent solids (where applicable), and the dilution factor, if any. The quantitation limits for additional analytes to this list may vary, depending upon the results of laboratory studies.

[b] *Test Methods for Evaluating Solid Waste*, U.S. Environmental Protection Agency, SW-846 Third Edition.

[c] Quantitation goals are set at 0.01 × the regulatory action level.

[d] Quantitation goals are set at 0.1 × the regulatory action level.

Accuracy and precision goals for field measurements of pH, conductivity, temperature, turbidity, and organic vapor concentration are listed in Table 3-2. Any direction or exceptions will be detailed in each activity-specific WD.

Analytical accuracy is expressed as the percent recovery of an analyte that has been added to a blank sample or environmental sample at a known concentration before analysis. Accuracy will be determined in the laboratory through the use of MS analyses, laboratory control sample (LCS) analyses, and blank spike analyses. The percent recoveries for specific target analytes will be calculated and used as an indication of the accuracy of the analyses performed.

Precision will be determined through the use of spike analyses conducted on duplicate pairs of environmental samples (MS/MSD) or comparison of positive duplicate pair responses. The relative percent difference (RPD) between the two results will be calculated and used as an indication of the precision of the analyses performed.

Sample collection precision will be measured in the laboratory by the analyses of field duplicates. Precision will be reported as the RPD for two measurements.

3.2.2.3 Completeness, Representativeness, and Comparability

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under normal conditions. It is expected that laboratories will provide data meeting QC acceptance criteria for all samples tested. Overall project completeness goals are identified in Tables 3-1 and 3-2.

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is a qualitative parameter that depends upon the proper design of the sampling program and proper laboratory protocol. The sampling network was designed to provide data representative of site conditions. During development of this guide, consideration was given to site history, past waste disposal practices, existing analytical data, physical setting and processes, and constraints inherent to this investigation. The rationale of the sampling design is discussed in detail in Sections 1.6 and 1.7.

Representativeness will be satisfied if the sampling network is properly designed and if the SAG is followed, proper sampling techniques are used, proper analytical procedures are followed, and holding times of the samples are not exceeded. Representativeness will be determined by assessing the combined aspects of the QA program, QC measures, and data evaluations.

Comparability expresses the confidence with which one data set can be compared with another. The extent to which analytical data will be comparable depends upon the similarity of sampling and analytical methods as well as sample to sample and historical comparability. Standardized and consistent procedures used to obtain analytical data are expected to provide comparable results. These new analytical data, however, may not be directly comparable to existing data because of differences in QA objectives.

3.3 General Sampling Procedures

It is anticipated that investigations performed at the St. Louis Sites may produce soil gas, surface soil, subsurface soil, sediment, storm water, surface water, ground-water, air filter, TLD, alpha track detectors for radon, carbon canister for radon flux, surface swipe, and IDW samples for analyses as appropriate to the specific investigation. Additional samples will be collected to complete field QC including duplicate, trip, rinsate and source water blanks. QA split samples will also be collected for analysis. Estimated numbers of samples (including activities and analytes) are incorporated into the applicable WD. Investigation samples may require VOC, SVOC, pesticide/PCB, metal, radionuclide, and other general determinations, as represented in Tables 3-1 and 3-2, and as detailed in activity-specific WDs. Sampling procedures for the various media under investigation are discussed in Section 2.0 of this SAG.

The primary field equipment and supporting materials to be used for these investigations are identified in Section 2.0 of this SAG. Several different types of field measurements may be performed during these investigations. Soil field measurements may determine soil classification and characteristics or volatile organic headspace gas concentrations. Ground-water field measurements may determine ground-water characteristics (pH, specific conductance, and temperature, etc.) and static ground-water levels. A description of the field instruments and associated calibration requirements and performance checks to be used for field measurements is presented Section 3.6 of this SAG.

The locations of the sampling stations and sample media to be collected during these investigations, and the rationales for the selection of these stations, will be presented in the activity-specific WDs.

3.3.1 General Information and Definitions

Subcontractor Laboratory

The laboratories subcontracted to perform analysis of samples have been selected through the USACE procurement and review process prior to field mobilization.

QA and QC Samples

These samples are analyzed for the purpose of assessing the quality of the sampling effort and of the reported analytical data. QA and QC samples to be used are duplicates, equipment rinsate blanks, trip blanks, source water blanks, and split samples. An example sample matrix is provided on Figure 3-2 to demonstrate a typical table, which would lay out the requirements for a site's sample set. The purpose of developing such tables is to assure that the project participants are aware of the numbers and types of samples and QC samples to be collected for each activity or task. An appropriate set of tables will be included in the WDs.

Field Duplicate QC Samples

These samples are collected by the sampling team for analysis by the on-site laboratory or contract laboratory. The identity of duplicate QC samples is held blind to the analysts and the purpose of these samples is to provide activity-specific, field-originated information regarding the homogeneity of the sampled matrix and the consistency of the sampling effort. These samples are collected concurrently with the primary environmental samples and equally represent the medium at a given time and location. Duplicate samples will be collected from each medium addressed by this project, and be submitted to the contractor laboratory for analysis.

USACE QA Split Samples

QA split samples for chemical analysis are collected by the sampling team and sent to a USACE QA laboratory for analysis to provide an independent assessment of contractor and subcontractor laboratory performance. The contractor will coordinate with the designated QA laboratory not less than 48 hours before sampling to ensure that the laboratory is alerted to receive the QA samples and process them within the time limits specified by applicable regulations and guidelines. QA split samples for radiological analysis will be collected by the contractor and submitted to the USACE-approved radiological QA laboratory.

Table 4.x St. Louis Site Surface Soil, Subsurface Soil, Sediment - Sampling and Analytical Requirements
BACKGROUND SURVEYS (planned samples/discretionary samples)

Parameters	Methods	Field Samples	Field Duplicate Samples	Site Source Water	Sampler Rinsates	Trip Blanks	Total A&E Samples	USACE QA Samples	USACE Trip Blanks
CHEMISTRY									
Volatile Organics, TCL	SW-846, 5035/8260B								
Semivolatile Organics, TCL	SW-846, 3550/8270C								
Pesticides/PCBs, TCL	SW-846, 3550/8081A								
Metals, TAL + Addtional	SW-846, 6010B/7471								
Metals, selected rare earths	SW-846, 6010B/6020								
Total Petroleum Hydrocarbons	SW-846, 9071/418.1								
Fluoride, leachable	SW-846, 9056 (mod.)								
Chloride, leachable	SW-846, 9056 (mod.)								
Nitrate, leachable	SW-846, 9056 (mod.)								
RADIOCHEMISTRY									
Uranium-234,235,238	Alpha Spec.								
Thorium-228,232	Alpha Spec.								
Radium-226,228	Gamma Spec.								
Protactinium-231	Gamma Spec.								
Actinium-227	Alpha Spec.								
Lead-210	EML PB01								
Tritium	Liquid Scint.								
Gamma Spectral Scan	Gamma Spec.								

Figure 3-2. Example Spreadsheet – Activity or Task Sample Matrix

Trip Blank Samples

These samples consist of containers of organic-free reagent water that are kept with the field sample containers from the time they leave the laboratory until they are returned for analysis. The purpose of trip blanks is to determine whether samples are being contaminated from VOCs during transit or sample collection. One trip blank will be placed into each cooler used to store and ship samples designated for volatile organic analysis. Trip blanks will also be used when transporting TLDs to the laboratory.

Equipment Rinsate Blanks

These samples will be taken from the water rinsate collected from equipment decontamination activities. They will comprise samples of analyte-free water, which have been rinsed over decontaminated sampling equipment, collected, and submitted for analysis of the parameters of interest. Equipment rinsate blanks are employed to assess the effectiveness of the decontamination process, the potential for cross contamination between sampling locations and incidental field contamination. No rinsate blanks are required for disposable or dedicated sampling equipment.

Source Water blanks

A sample from the site water supply used for equipment decontamination, well development, and other activities will be acquired and submitted for analysis with the primary samples. In addition, samples of on-site analyte-free water sources may also be submitted for analysis. For radon flux sampling, un-deployed carbon canisters will be submitted for analysis with the exposed canisters. Generally, no more than one sample is needed for a sampling task.

3.3.2 Sample Containers, Preservation Procedures, and Holding Times

Sample containers, chemical preservation techniques, and holding times for soils and waters, air, and direct radiation monitoring collected during investigations are described in Tables 2-1, 2-2, and 2-3. The specific number of containers required for each study should be estimated and supplied by the analytical facilities. Additional sample volumes should be collected and provided, when necessary, for the express purpose of performing associated laboratory QC (laboratory duplicates, MS/MSD).

All sample containers should be provided by the analytical support laboratories, which should also provide the required types and volumes of preservatives with containers as they are delivered. Temperature preservation, when required (e.g. for samples to be analyzed for VOC, SVOC and other organic analyses), will be maintained at 4°C (±2°C) immediately after collection and will be maintained at this temperature until the samples are analyzed. Some laboratories utilize temperature blanks to confirm temperature preservation of the samples. If needed, these blanks should be placed into the cooler along with the samples. In the event that sample integrity, such as holding times, and cooler temperatures, is compromised, resampling may occur as directed by the USACE Task/Technical Lead. Any affected data will be flagged and qualified per data validation instructions and guidance.

3.3.3 Field Documentation

3.3.3.1 Field Logbooks

Sufficient information should be recorded in the field logbooks to permit reconstruction of all drilling and sampling activities conducted. Information recorded on other project documents should not be repeated in the logbooks, except in summary form where determined necessary. All field logbooks will be kept in the possession of field personnel responsible for completion, or in a secure place when not being used during fieldwork. Upon completion of the field activities, all logbooks should be submitted to USACE to become part of the final project file. Guidance for documenting specific types of field sampling activities in field logbooks are provided in Appendix C of EM-200-1-3 (USACE, 1994c).

3.3.3.2 Sample Numbering System

A unique sample numbering scheme will be used to identify each sample collected, following the general outline established on Figure 3-3. The purpose of this numbering scheme is to provide a tracking system for the retrieval of analytical and field data on each sample. Sample identification numbers will be used on all sample labels or tags, field data sheets or logbooks, chain-of-custody records, and all other applicable documentation used during each project. A listing of all sample identification numbers should be maintained in the field logbook. The project database should be pre-populated with sample numbers and information consistent with instructions found in Section 4.0, of the DMPP.

The sample-numbering scheme used for field samples should be employed for duplicate samples and other field QC such that they will not be readily discernable by the laboratory. The sample-numbering scheme to be used for each project may be detailed in WDs.

3.3.3.3 Documentation Procedures

Labels will be affixed to all sample containers during sampling activities. Information will be recorded on each sample container label at the time of sample collection. The information to be recorded on the labels will be as follows:

- Contractor name;
- Sample identification number;
- Sample type (discrete or composite);
- Site name and sample station number;
- Analysis to be performed;
- Type of chemical preservative present in container;
- Date and time of sample collection; and
- Sampler's name and initials.

Sample logbooks and chain-of-custody records should contain the same information as the labels affixed to the containers. These records will be maintained and record all information related to the sampling effort and the process employed. The tracking procedure to be used for documentation of all samples collected during the project will involve the steps outlined in Section 4.0 of the DMPP.

Figure 3-3. Unique Sample Identification System for St. Louis FUSRAP Sites

XXX##### - Format to be used for sample collection and delivery to laboratory

XXX-AAAmmNNNNn-##### - Format to be used for database and reporting

XXX = Site Designator
St. Louis Downtown Site = SLD
St. Louis Airport Site = SLA
SLAPS Vicinity Properties = SVP
Hazelwood Interim Storage Site = HIS
Coldwater Creek Watershed = CWC
Hot Zones = HTZ
Utility Work = UTW

AAA = Area Designator
Investigation Area 1 = IA1 (example IA1 - IA9; then A10 - A99; or others as identified)
Background = BKG
Final Status Survey Soil Sample = ITD
etc. (can include designators for vicinity or contiguous properties)

mm = Media
Surface Soil = SS
Subsurface Soil = SB
Sediment = SD
Ground Water = GW
Surface Water = SW
Storm Water = ST
Aquatic Biota = AB
Terrestrial Biota = TB
Air Filter (Area) = AA
Air Filter (Environmental) = AE
Air Filter (Personal) = AP
Radon Detector = RD
Radon Flux = RF
TLDs = TD
Quality Control = QC
etc. (as new media types are identified)

NNNN = Station Number
Unique Station Identifier

n = Sample Type
Regular = 0
Duplicate = 1
Split = 2
Trip Blank = 3
Equipment Rinsate = 4
Site Source Water Blank = 5

= Sequential Sample Number
Unique to each site

3.3.3.4 Field Variance System

Procedures cannot fully encompass all conditions encountered during a field investigation; therefore, variances from the operating procedures, WD, and/or SSHP may occur. All variances that occur during field investigations should be documented on a USACE Record of Technical Direction Form (TDF) and will be noted in the appropriate field logbooks. Examples of the TDF (Figure 3-4) to be used for these investigations are presented in this SAG. If a variance is anticipated (e.g., because of a change in the field instrumentation), the applicable procedure should be modified and the change noted in the field logbooks.

3.4 Sample Custody

It is the policy of USACE and will be the intent of these investigations to follow EPA policy regarding sample custody and chain-of-custody protocols as described in *NEIC Policies and Procedures* (EPA, 1986a). This custody is in three parts: sample collection, laboratory analysis, and final evidence files. Final evidence files, including originals of laboratory reports and electronic files, are maintained under document control in a secure area. A sample or evidence file is under your custody when it is:

- In your possession;
- In your view, after being in your possession;
- In your possession and you place them in a secured location; and/or
- In a designated secure area.

3.4.1 Sample Documentation

The sample packaging and shipment procedures summarized below should ensure that samples will arrive at the laboratory with the chain-of-custody intact. The protocol for specific sample numbering using case numbers and traffic report numbers (if applicable) and other sample designations will be followed.

3.4.1.1 Field Procedures

The field sampler is responsible for the care and custody of the samples until they are transferred or properly dispatched. As few people as possible should handle the samples. Each sample container will be labeled with a sample number, date and time of collection, sampler, and sampling location. Sample labels are to be completed for each sample. The Project Manager, in conjunction with USACE, should review all field activities to determine whether proper custody procedures were followed during the fieldwork and to decide if additional samples are required.

3.4.1.2 Field Logbooks/Documentation

Samples will be collected following the sampling procedures documented in this SAG, QAPP, and the activity-specific WD. When a sample is collected or a measurement is made, a detailed description of the location will be recorded. The equipment used to collect samples will be noted, along with the time of sampling, sample description, depth at which the sample was collected, volume, and number of containers. A sample identification number should be assigned

RECORD OF TECHNICAL DIRECTION

Contract:	**Task Order No./Title:**
Description of Change:	
Justification:	
Impact on Overall Project Cost & Schedule:	
Submitted by:	**Date:**
Requested by: (USACE)	**Date:**
Concurred by:	**Date:**
Concurred by: (USACE-TM)	**Date:**
Approved by: (USACE-COR)	**Date:**

Please check one.

____ **In Scope, within budget, funds obligated**

____ **In Scope, within budget, but funds not obligated**

____ **In Scope, within budget, funds obligated, provides direction change/clarification**

____ **In Scope, budgeted funds exceeded or will be exceeded by new or expanded task**

____ **In Scope, obligated funds exceeded or will be exceeded by new or expanded task**

____ **Out of Scope (i.e. no task item)**

Figure 3-4. Example of USACE Record of Technical Direction Form

before sample collection. Field duplicate samples and QA split samples, which should receive an entirely separate sample identification number, will be noted under sample description. Equipment employed to make field measurements will be identified along with calibration dates.

3.4.1.3 Transfer of Custody and Shipment Procedures

Samples are accompanied by a properly completed chain-of-custody form. The sample numbers/location (sample ID), date/time collected, matrix, requested analyses, screening data, preservatives (other than ice) and any other pertinent comments about the sample will be listed on the chain-of-custody form. When submitting samples for analysis, a sampling event description (such as "Verification", "Investigation", "Background" etc.) should also be added to the chain-of custody record in the "Comments" section. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record will document transfer of custody of samples from the sampler to another person, to a transporter, to a mobile laboratory, to the permanent laboratory, or to/from a secure storage area. An example of the chain-of-custody form to be used for these investigations is illustrated in Figure 3-5.

All shipments will be accompanied by a chain-of-custody record, which identifies the contents. The original record will accompany the shipment, and copies will be retained by the sampler for return to project management and the project file. Whenever co-located or split samples are collected for comparison analysis by the USACE QA Laboratory or a government agency, a separate chain-of-custody is prepared for those samples and marked to indicate with whom the samples are being split.

All shipments must be in compliance with applicable United States Department of Transportation (DOT) regulations for environmental samples. Shipment of samples on Friday should be discouraged unless it is absolutely necessary and the laboratory has confirmed that personnel will be present on Saturday to receive and implement any necessary processing within the analytical holding times.

3.4.2 Laboratory Chain-of-Custody Procedures

Custody procedures, along with the holding time and sample preservative requirements for samples, will be described in laboratory QA Plans. These documents should identify the laboratory custody procedures for sample receipt and log-in, sample storage, tracking during sample preparation and analysis, and laboratory storage of data.

3.4.2.1 Cooler Receipt Checklist

The condition of shipping coolers and enclosed sample containers should be documented upon receipt at the analytical laboratory. This documentation should be accomplished using the cooler receipt checklist presented on Figure 3-6. One of these checklists should be placed into each shipping cooler along with the completed chain-of-custody form or provided to the laboratory at the start of the project. A copy of the checklist should be faxed to the Project Manager immediately after it has been completed at the laboratory. The original completed checklist may be transmitted with the final analytical results from the laboratory.

Chain of Custody Record

DO #:
PO #:
COC #:
SDG #:
Page 1 of 1 Date:

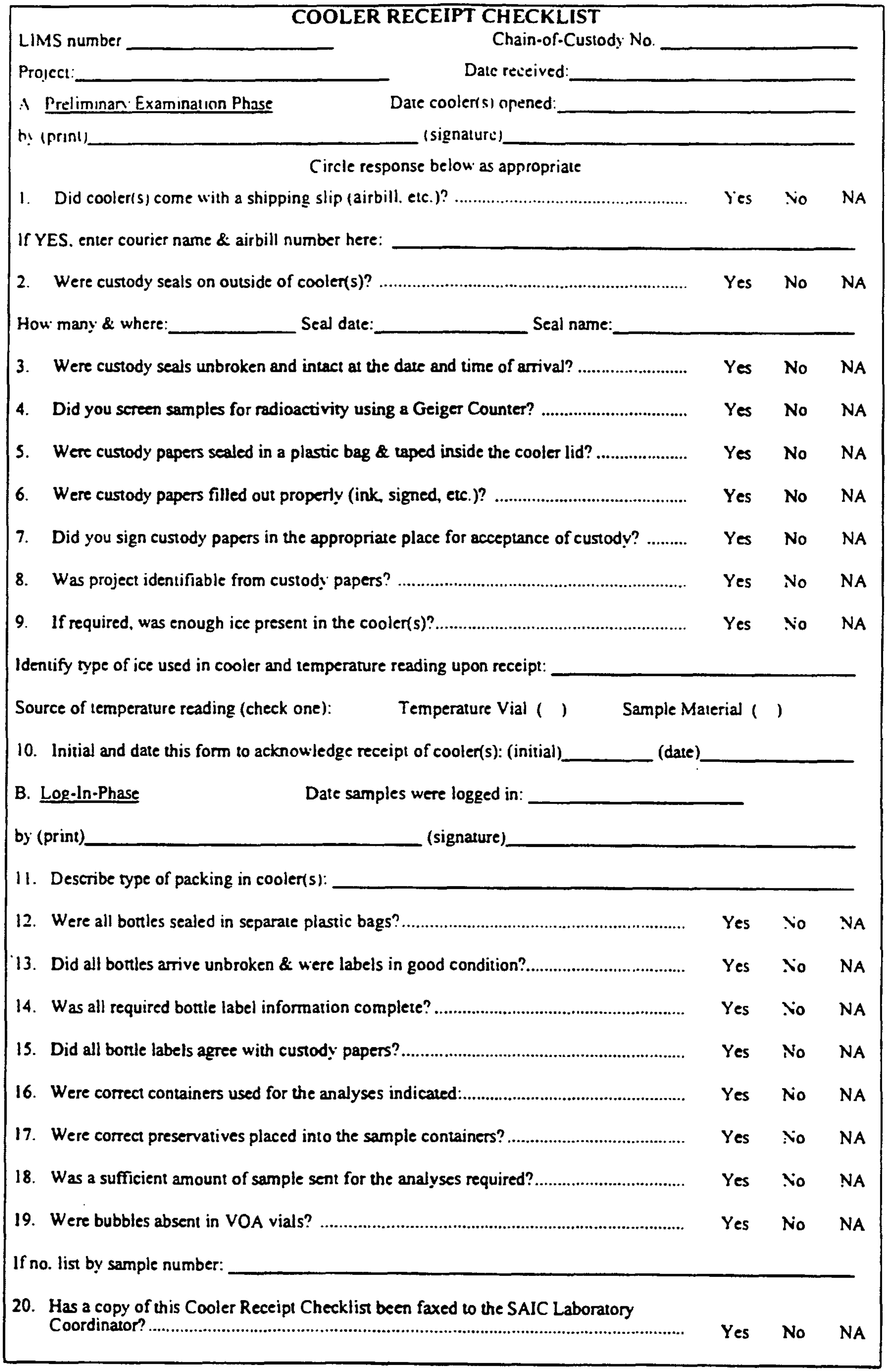
CONTRACTOR: SAIC
ADDRESS: 500 Northwest Plaza, Suite 1250
St. Ann, MO 63074
PHONE NUMBER: (314) 209-2950
CONTACT NAME:
PROJECT NAME:
SAMPLING EVENT NAME:

LABORATORY NAME:
Quanterra
ADDRESS:
13715 Rider Trail North
Earth City, MO 63075
PHONE NUMBER: (314)298-8566
CONTACT NAME:
John Powell

								Requested Analyses															
Sample ID #	Station	Date	Time	Container	Pres.	Depth	Matrix																OBSERVATIONS, COMMENTS, SPECIAL INSTRUCTIONS

Relinquished By:	Date:	Time:	Received By:	Date:	Time:

Total # of Containers:
# of containers this pg.:
Shipment Method:
Airbill/Waybill #:



COOLER RECEIPT CHECKLIST

LIMS number ____________ Chain-of-Custody No. ____________

Project: ____________ Date received: ____________

A. Preliminary Examination Phase Date cooler(s) opened: ____________

by (print) ____________ (signature) ____________

Circle response below as appropriate

1. Did cooler(s) come with a shipping slip (airbill, etc.)? .... Yes No NA

If YES, enter courier name & airbill number here: ____________

2. Were custody seals on outside of cooler(s)? .... Yes No NA

How many & where: ____________ Seal date: ____________ Seal name: ____________

3. Were custody seals unbroken and intact at the date and time of arrival? .... Yes No NA
4. Did you screen samples for radioactivity using a Geiger Counter? .... Yes No NA
5. Were custody papers sealed in a plastic bag & taped inside the cooler lid? .... Yes No NA
6. Were custody papers filled out properly (ink, signed, etc.)? .... Yes No NA
7. Did you sign custody papers in the appropriate place for acceptance of custody? .... Yes No NA
8. Was project identifiable from custody papers? .... Yes No NA
9. If required, was enough ice present in the cooler(s)? .... Yes No NA

Identify type of ice used in cooler and temperature reading upon receipt: ____________

Source of temperature reading (check one): Temperature Vial ( ) Sample Material ( )

10. Initial and date this form to acknowledge receipt of cooler(s): (initial) ____________ (date) ____________

B. Log-In-Phase Date samples were logged in: ____________

by (print) ____________ (signature) ____________

11. Describe type of packing in cooler(s): ____________
12. Were all bottles sealed in separate plastic bags? .... Yes No NA
13. Did all bottles arrive unbroken & were labels in good condition? .... Yes No NA
14. Was all required bottle label information complete? .... Yes No NA
15. Did all bottle labels agree with custody papers? .... Yes No NA
16. Were correct containers used for the analyses indicated: .... Yes No NA
17. Were correct preservatives placed into the sample containers? .... Yes No NA
18. Was a sufficient amount of sample sent for the analyses required? .... Yes No NA
19. Were bubbles absent in VOA vials? .... Yes No NA

If no, list by sample number: ____________

20. Has a copy of this Cooler Receipt Checklist been faxed to the SAIC Laboratory Coordinator? .... Yes No NA

Figure 3-6. Example of a Cooler Receipt Checklist

3.4.2.2 Letter of Receipt

The laboratory will confirm sample receipt and log-in information through transmission of a Letter-of-Receipt (LOR) to the Project Manager. This should include returning a copy of the completed chain-of-custody, a copy of the cooler receipt checklist, and confirmation of the analytical log-in indicating laboratory sample and sample delivery group numbers.

3.4.3 Final Evidence Files Custody Procedures

The contractor is the custodian of the evidence file and will maintain the contents of evidence files for these investigations, including all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, correspondence, laboratory logbooks, and chain-of-custody forms. The evidence file will be stored in a secure, limited-access area and under custody of the Project Manager or designee.

Analytical laboratories will retain all original raw data information (both hard copy and electronic) in a secure, limited-access area and under custody of the Laboratory Project Manager.

3.4.4 Storage/Archival of Samples

The primary laboratories shall have procedures describing long-term storage/archival of samples and documentation on the storage conditions of all samples, sample extracts and digestates. These entities shall not be placed in long-term storage/archival until acceptance of the final data package by the USACE, and shall remain in storage in predetermined physical and environmental conditions commensurate with their intended purpose.

Long-term storage/archival areas shall be controlled for access and to prevent damage and loss, maintain sample container and identification integrity, and comply with appropriate environmental, safety, and health requirements and policies. Removal and/or disposition of samples from long-term storage/archival shall not take place prior to the primary laboratories receiving written approval from the USACE.

3.5 Analytical Procedures

All samples collected during these investigations will be analyzed by USACE-approved laboratories and should be reviewed and validated. QA samples will be collected for ground water, soil, air, and direct radiation monitoring and should be analyzed by the designated USACE QA Laboratory. Each laboratory supporting this work should provide statements of qualifications including organizational structure, QA Manual, and SOPs.

3.5.1 Laboratory Analysis

Samples collected during these investigations should be analyzed by EPA SW-846 methods and other documented EPA or nationally recognized methods. Laboratory standard operating procedures are based on the methods as published by the EPA in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 1993b). Analytical parameters, methods, and quantitation or detection limits are listed in Tables 3-3 and 3-4. The activity-specific WDs must identify the list of parameters of concern for a particular task or program, and any variations in the methods or limits should be identified in Table 3-3 and 3-4.

Principal laboratory facilities should not subcontract or transfer any portion of this work to another facility, unless expressly permitted to do so in writing by the USACE Task/Technical Lead.

If contaminant concentrations are high, or for matrices other than normal waters and soils, analytical protocols may be inadequate. In these cases, the analytical methodology may require modifications on the basis of the results of sample analyses. Any proposed changes to analytical methods specified require written approval from the contractor and USACE. All analytical method variations must be identified in activity-specific WDs.

These may be submitted for regulatory review and approval when directed by the USACE Task/Technical Lead.

These SOPs must be adapted from and referenced to standard methods and thereby specify:

- Procedures for sample preparation;
- Instrument start-up and performance check;
- Procedures to establish the maximum detection limit (MDL) and PQL for each parameter;
- Initial and continuing calibration check requirements;
- Specific methods for each sample matrix type;
- Required analyses and QC requirements.

3.5.2 Field Screening Analytical Protocols

Calibration procedures for field measurement of pH, specific conductivity, temperature, beta/gamma activity are described in Section 3.6. Tabulation of the analytical methods appears in Tables 3-1 and 3-2.

3.6 Calibration Procedures and Frequency

This section describes procedures for maintaining the accuracy of all the instruments and measuring equipment that are used for conducting field tests and laboratory analyses. These instruments and equipment will be calibrated before each use or on a scheduled, periodic basis according to manufacturer instructions.

3.6.1 Field Instruments/Equipment

Instruments and equipment used to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications. All field instruments for this purpose should have unique identifiers, and each instrument will be logged in a measuring and testing equipment (M&TE) logbook (or equivalent documentation) before use in the field. The

SSHO or his/her designate will be responsible for performing and documenting daily calibration/checkout records for instruments used in the field.

Equipment to be used during field sampling will be examined to certify that it is in operating condition. This should include checking the manufacturer's operating manual and instructions for each instrument to ensure that all maintenance requirements are being observed. Field notes from previous sampling trips should be reviewed so that the notation on any prior equipment problems will not be overlooked, and all necessary repairs to equipment will be carried out. Spare parts or duplication of equipment should be available to the sampling effort.

Calibration of field instruments is governed by the specific SOP for the applicable field analysis method, and should be performed at the intervals specified in the SOP. If no SOP is available, calibration of field instruments will be performed at intervals specified by the manufacturer or more frequently as conditions dictate. Calibration procedures and frequency should be recorded in a field logbook.

Field instruments may include (as appropriate to the specific investigation) a pH meter, temperature probe, specific conductivity meter, hand-held scintillation detectors for radioactivity screening levels, photoionization detectors (PIDs) or flame ionization detectors (FIDs) for organic vapor detection, and geophysical equipment. If an internally calibrated field instrument fails to meet calibration/checkout procedures, it should be returned to the manufacturer for service and a backup instrument may be calibrated and used in its place. Field instrument uses, detection levels, and calibration are summarized in Table 3-5.

Detailed instructions on the proper calibration and use of each field instrument follow the guidelines established by the manufacturer. The technical procedures for each instrument used on this project include the manufacturer's instructions detailing the proper use and calibration of each instrument.

pH Meter Calibration

The pH meter will be calibrated according to the manufacturer's instructions using traceable standard buffer solutions before work in the field. Calibration should generally follow these steps:

- Temperature of sample and buffer should be the same;
- Connect pH electrode into pH meter and turn on pH meter;
- Adjust temperature setting based on the temperature of buffer; place electrode in first buffer solution;
- After reading has stabilized, adjust "CALIB" knob to display correct value;
- Repeat procedure for second buffer solution;
- Place pH electrode in the sample and record the pH as displayed;
- Remove pH electrode from sample and rinse off with distilled water; and
- Re-calibrate the pH meter every time it is turned off and turned back on, or if it starts giving erratic results.

Table 3-5. Field Instrument Uses, Detection Limits, and Calibration

Instrument	Uses	Detection Limits	Calibration	Comments
Total organic vapor meters	Sample screening for VOCs	PID - 0.2 ppm benzene or	1 point - PID benzene daily	Action level must be stated in Health and Safety Plan
	Health and safety screening	FID - 1.0 ppm methane	1 point - FID methane daily	Instrument cannot differentiate naturally occurring compounds from contaminants
			Verification check every 20 samples	PID cannot detect compounds with ionization potentials > 11 eV
Radiological monitoring	Monitoring of beta-gamma surface, gross gamma, alpha surface contamination levels	Daily calibration check varies by equipment	Daily source check per manufacturer	Validation labels include minimum and maximum acceptable levels
pH meters	Field screening of waters	N/A	2 points with standards at pH 7.0 and 4.0 or pH 7.0 and 10.0 daily	Accuracy is to ∀ 0.5 pH units
Temperature (in-line)	Determining water temperature	N/A	To manufacturer instructions	
Conductivity meter	Determining conductivity of water	N/A	1 point in KCL solution	Calculations and acceptance criteria must be available in the field
Membrane electrode meter	Determining dissolved oxygen levels	N/A	1 point using calculated value for water at ATP at least once every 3 hours	Accuracy is ∀ 0.01 ppm
Turbidometer	Determining turbidity levels in water	1 NTU	1 point standardization formazin turbidity suspension	Accuracy is ± 2 NTU

VOCs = volatile organic compounds
PID = photoionization detector
ppm = parts per million
FID = flame ionization detector
N/A = not applicable
NTU = nephelometric turbidity unit

Before use in the field, calibration of the pH meter will be checked against two standard buffer solutions. Calibration procedures, lot numbers of buffer solutions, and other pertinent calibration or checkout information should be recorded in the M&TE logbook for the project. The calibrations performed, standards used, and sample pH values will be recorded in the field logbook. Appropriate new batteries should be purchased and kept with the meters to facilitate immediate replacement in the field as necessary.

Temperature Calibration

Temperature measurements should be carried out using a temperature probe. Mercury thermometers must be inspected before use to ensure that there is no mercury separation. Thermometers will be rechecked in the field before and after each use to see if the readings are logical and the mercury is still intact. All temperature probes will be checked biannually for calibration by immersing them in a bath of known temperature until equilibrium is reached. Temperature probes should be replaced if found to have more than 10 percent error. The reference thermometer used for bath calibration should be National Institute of Standards and Technology (NIST) traceable. Temperatures will be recorded in the M&TE logbook, the sample logbook, or the cooler logbook, as appropriate.

Conductivity Meter Calibration

The conductivity cells of the specific conductivity meter will be cleaned according to manufacturer's recommendations and specifications and checked against known conductivity standard solutions before each sampling event. The instrument should be checked daily with NIST-traceable standard solutions. If the instrument is more than 10 percent out of calibration when compared with standard solutions, the instrument will be re-calibrated. If this cannot be done in the field, the instrument should be returned to the manufacturer or supplier for re-calibration and a backup instrument should be used in its place. Daily calibration readings and other relevant information will be recorded daily in the M&TE logbook.

Daily checks should be as follows:

- Fill a sample cup with the conductivity calibration standard solution;
- Set temperature knob for temperature of standard solution;
- Turn to appropriate scale and set the instrument for the value of calibration standard; and
- Rinse out the cup with distilled water.

Organic Vapor Detection

OVA's will be checked daily according to the manufacturer's instructions. FIDs will be checked daily by using the internal calibration mechanism. PIDs should be calibrated daily with a gas of known concentration. All daily calibration information will be recorded in the M&TE logbook.

Radiation Monitoring

Radiation detectors will be checked daily according to the manufacturer's instructions. Meters will be checked daily using calibration source checks appropriate for the given instrument, based on the type, energy and intensity of the radiation to be measured. Meters will be calibrated at least annually with calibration dates clearly identified on each instrument. All daily calibration check in formation should be recorded in the M&TE logbook.

Turbidity Calibration

The turbidity meter should be calibrated each day against a known and traceable standard supplied by the manufacturer prior to use in the field. In the field, the instrument should be checked against the standard and adjusted each time the instrument is turned on. Calibration information will be recorded in the M&TE logbook; checks made in the field should be recorded in the sample logbook.

Dissolved Oxygen Calibration

The dissolved oxygen meter will be calibrated each day against a calculated value for tap water open to the air based on temperature and barometric pressure. In the field, the instrument should be checked against the calculated value and adjusted daily. Calibration information will be recorded in the M&TE logbook.

3.6.2 Laboratory Instruments

Calibration of laboratory equipment will be based on approved written procedures. Records of calibration, repairs, or replacement will be filed and maintained by laboratory personnel performing QC activities. These records will be filed at the location where the work is performed and will be subject to QA audit. Procedures and records of calibration will follow USACE and contractor-reviewed laboratory-specific QA Plans.

In all cases where analyses are conducted according to the EPA CLP or SW-846 protocols, the calibration procedures and frequencies specified in the applicable CLP RAS Statement of Work (SOW) or SW-846 methods will be followed exactly. For analyses governed by SOPs, refer to the appropriate SOP for the required calibration procedures and frequencies.

Records of calibration will be kept as follows:

- Each instrument will have a record of calibration with an assigned record number.
- A label will be affixed to each instrument showing identification numbers, manufacturer, model numbers, date of last calibration, signature of calibrating analyst, and due date of next calibration. Reports and compensation or correction figures will be maintained with instrument.
- A written step-wise calibration procedure will be available for each piece of test and measurement equipment.

- Any instrument that is not calibrated to the manufacturer's original specification will display a warning tag to alert the analyst that the device carries only a "Limited Calibration."

3.7 Internal Quality Control Checks

3.7.1 Field Sample Collection

The assessment of field sampling precision and accuracy will be made by collecting and analyzing field duplicates, MS/MSDs, rinsate blanks and trip blanks in accordance with the procedures described in the Section 3.2.2.

3.7.2 Field Measurement

QC procedures for most field measurements (e.g., pH, conductivity, temperature, activity levels, and headspace) are limited to checking the reproducibility of the measurement by obtaining multiple readings on a single sample or standard and by calibrating the instruments. Refer to Section 3.6 of this QAPP for more detail regarding these measurements.

3.7.3 Laboratory Analysis

Analytical QC procedures for these investigations are specified in the individual method descriptions. These specifications include the types of QC checks normally required, such as method blanks, LCS, MS, MSD, calibration standards, internal standards, surrogate standards, tracer standards, calibration check standards, and laboratory duplicate analysis. Calibration compounds and concentrations to be used and the method of QC acceptance criteria for these parameters have been identified.

To ensure the production of analytical data of known and documented quality, laboratories associated with these investigations must implement all method QA and QC checks.

3.7.3.1 QA Program

All subcontracted analytical laboratories will have a written QA program that provides rules and guidelines to ensure the reliability and validity of work conducted at the laboratory. Compliance with the QA program is coordinated and monitored by the laboratory's QA department, which is independent of the operating departments. For these investigations, selected support laboratory QA plans will be referenced and implemented in their entirety.

The stated objectives of the laboratory QA program are to:

- Properly collect, preserve, and store all samples;
- Maintain adequate custody records from sample collection through reporting and archiving of results;
- Use properly trained analysts to analyze all samples by approved methods within holding times;
- Produce defensible data with associated documentation to show that each system was calibrated and operating within precision and accuracy control limits;

- Accurately calculate, check, report, and archive all data using the Laboratory Information Management System; and
- Document all of the above activities so that all data can be independently validated.

All laboratory procedures are documented in writing as SOPs, which are edited and controlled by the QA department. Internal QC measures for analysis will be conducted with the laboratory's SOPs and the individual method requirements specified.

External QA "split" samples should be provided by the USACE QA Laboratory. The external QA Laboratory may receive QA sample splits as identified in the activity-specific WD.

3.7.3.2 QC Checks

Implementation of QC procedures during sample collection, analysis, and reporting ensures that the data obtained are consistent with their intended use. Both field QC and laboratory QC checks are performed throughout the work effort to generate data confidence. Analytical QC measures are used to determine if the analytical process is in control, as well as to determine the sample matrix effects on the data being generated.

Field QC check samples should be clearly identified in the WD, and will include identification of field duplicate samples, source water blanks, rinsate blanks, and trip blanks. Analytical method specifications include the types of laboratory QC checks required (replicates, sample spikes, surrogate spikes, reference samples, controls, method blanks, etc.), the frequency for implementation of each QC measure, compounds to be used for sample spikes and surrogate spikes, and the acceptance criteria for this QC.

Laboratories must provide documentation in each data package that both initial and ongoing instrument and analytical QC functions have been met. Any nonconforming analysis should be reanalyzed by the laboratory, if sufficient sample volume is available. It is expected that sufficient sample volumes will be collected to provide for reanalyses, if required.

Analytical Process QC

Method Blanks

A method blank is a non-contaminated sample of the matrix of interest (usually distilled/deionized water or silica sand) that is then subjected to all of the sample preparation (digestion, distillation, extraction) and analytical methodology applied to the samples. The purpose of the method blank is to check for contamination from within the laboratory that might be introduced during sample preparation and analysis that would adversely affect analytical results. A method blank must be analyzed with each analytical sample batch.

Analytical detection limit goals are identified in Tables 3-3 and 3-4 as PQL's. Method blank levels should be below the PQL for all analytes. Method blank levels are considered acceptable if they are less than 2 times the quantitation limits. The activity-specific WDs should identify any modification to these limits, with justification for the particular task or program.

Laboratory Control Samples (LCS)

The LCS contain known concentrations of analytes representative of the contaminants to be determined and are carried through the entire preparation and analysis process. Commercially available LCSs or those available from EPA may be used. LCS standards that are prepared in-house must be made from a source independent of that of the calibration standards. Each LCS analyte must be plotted on a control chart. The primary purpose of the LCS is to establish and monitor the laboratory's analytical process control. A LCS must be analyzed with each analytical sample batch.

Matrix and Sample-Specific QC

Laboratory Duplicates

Laboratory duplicates are separate aliquots of a single sample that are prepared and analyzed concurrently at the laboratory. This duplicate sample should not be a method blank, trip blank, or source water blank. The primary purpose of the laboratory duplicate is to check the precision of the laboratory analyst, the sample preparation methodology, and the analytical methodology. If there are significant differences between the duplicates, the affected analytical results should be reexamined. One in 20 samples should be a laboratory duplicate, with fractions rounded to the next whole number.

Surrogate Spikes

A surrogate spike is prepared by adding a pure compound(s) to a sample before extraction. The compounds in the surrogate spike should be of a similar type to that being assayed in the sample. The purpose of a surrogate spike is to determine the efficiency of recovery of analytes in the sample preparation and analysis. The percent of recovery of the surrogate spike is then used to gauge the total accuracy of the analytical method for that sample.

Isotopic Tracers

An isotopic tracer is prepared by adding a unique isotope of the same or similar element to a sample before preparation and analysis. The purpose of this isotopic tracer is to determine the efficiency of recovery of the targeted isotope or isotopes in the sample preparation and analysis. The percent of recovery of the tracer is then used to gauge the total accuracy of the analytical method for that sample and to compensate for the quantification of the analyte of interest.

Matrix Spikes (MS) and Matrix Spike Duplicates (MSD)

The MS and MSD are aliquots of a sample spiked in the same manner, with known quantities of analytes and subjected to the entire analytical procedure. It is used to indicate the appropriateness of the method for the matrix by measuring recovery or accuracy. Accuracy is the nearness of a result or the mean of a set of results to the true or accepted value. The purpose of the MSD, when compared to the MS, is to determine method precision. Precision is the measure of the reproducibility of a set of replicate results among themselves or the agreement among repeat observations made under the same conditions. MSs and MSDs are performed per 20 samples of similar matrix.

Method-Specific QC

The laboratory must follow specific quality processes as defined by the method. These may include measures such as calibration verification samples, instrument blank analysis, internal standards implementation, tracer analysis, method of standard additions utilization, serial dilution analysis, post-digestion spike analysis, and chemical carrier evaluation.

3.8 Calculation of Data Quality Indicators

3.8.1 Field Measurements Data

Field data should be assessed by the CQC Representative. The CQC Representative will review the field results for compliance with the established QC criteria that are specified in the SAG, QAPP, and activity-specific WD. Accuracy of the field measurements will be assessed using daily instrument calibration, calibration check, and analysis of blanks. Precision will be assessed on the basis of reproducibility by multiple reading of a single sample.

Field data completeness will be calculated using Equations 1a and 1b.

Sample Collection (1a):

$$\text{Completeness} = \frac{\text{Number of Sample Points Sampled}}{\text{Number of Sample Points Planned}} \times 100\% \qquad \textbf{Equation 1a}$$

Field Measurements (1b):

$$\text{Completeness} = \frac{\text{Number of Valid Field Measurements Made}}{\text{Number of Field Measurements Planned}} \times 100\% \qquad \textbf{Equation 1b}$$

3.8.2 Laboratory Data

Laboratory results will be assessed for compliance with required precision, accuracy, completeness, and sensitivity as follows.

3.8.2.1 Precision

The precision of the laboratory analytical process will be determined through evaluation of LCS analyses. The standard deviation of these measurements over time will provide confidence that implementation of the analytical protocols was consistent and acceptable. These measurements will establish the precision of the laboratory analytical process.

Investigative sample matrix precision should be assessed by comparing the analytical results between MS/MSD for organic analysis and laboratory duplicate analyses for inorganic analysis. The RPD will be calculated for each pair of duplicate analyses using Equation 2 below, which will produce an absolute value for RPD. This precision measurement will include variables associated with the analytical process, influences related to sample matrix interferences, and sample heterogeneity.

$$RPD = \frac{S - D}{\frac{(S + D)}{2}} x\ 100, \qquad \textbf{Equation 2}$$

where:

S = first sample value (original or MS value),
D = second sample value (duplicate or MSD value).

3.8.2.2 Accuracy

The accuracy of the laboratory analytical measurement process will be determined by comparing the percent recovery for the LCS versus its documented true value.

Investigative sample accuracy should be assessed for compliance with the established QC criteria that are described in Section 3.2, together with the activity-specific WD, using the analytical results of method blanks, reagent/preparation blank, MS/MSD samples, rinsate blank, and bottle blanks. The percent recovery (%R) of MS samples will be calculated using Equation 3 below. This accuracy will include variables associated with the analytical process, influences related to sample matrix interferences, and sample heterogeneity.

$$\%R = \frac{A - B}{C} \times 100 \qquad \textbf{Equation 3}$$

where:

A = the analyte concentration determined experimentally from the spiked sample,
B = the background level determined by a separate analysis of the un-spiked sample,
C = the amount of the spike added.

3.8.2.3 Completeness

Data completeness of laboratory analyses will be assessed for compliance with the amount of data required for decision making. The completeness is calculated using Equation 4 below.

$$\text{Completeness} = \frac{\text{Number of Valid Laboratory Measurements Made}}{\text{Number of Laboratory Measurements Planned}} \times 100\% \qquad \textbf{Equation 4}$$

3.8.2.4 Sensitivity

Achieving MDLs depends on sample preparation techniques, instrument background levels, instrument sensitivity, and matrix effects. Therefore, it is important to determine actual MDLs through the procedures outlined in 40 CFR 136, Appendix C. MDLs should be established for each major matrix under investigation (e.g., water, soil) through multiple determinations, leading to a statistical evaluation of the MDL.

It is important to monitor instrument sensitivity through calibration blanks and low concentration standards to ensure consistent instrument performance. It is also critical to monitor the analytical method sensitivity through analysis of method blanks, calibration check samples, LCSs, etc.

3.8.3 Project Completeness

Project completeness should be determined by evaluating the planned versus actual data. Consideration will be given for project changes and alterations during implementation. All data not flagged as rejected by the review, verification, validation, or assessment processes will be considered valid. Overall, the project completeness will be assessed relative to media, analyte, and area of investigation. Completeness objectives for soil are listed in Table 3-1 and for water in Table 3-2.

3.8.4 Representativeness/Comparability

Representativeness expresses the degree to which data accurately reflect the concentration of the analyte or parameter of interest for the environmental media examined at the site. It is a qualitative term most concerned with the proper design of the sampling program. Factors that affect the representativeness of analytical data include appropriate number and location of samples, proper sample collection and preservation techniques, analytical holding times, use of standard analytical methods, and determination of matrix or analyte interferences. Sample collection, preservation, analytical holding time, analytical method application, and matrix interferences will be evaluated by reviewing project documentation and QC analyses.

Comparability, like representativeness, is a qualitative term relative to a project data set as an individual. These investigations should employ narrowly defined sampling methodologies, site audits/surveillances, use of standard sampling devices, uniform training, documentation of sampling, standard analytical protocols/procedures, QC checks with standard control limits, and universally accepted data reporting units to ensure comparability to other data sets. Through proper implementation and documentation of these standard practices, the project should establish confidence that data will be comparable to other project and programmatic information.

Additional input to determine representativeness and comparability may be gained through statistical evaluation of data populations, chemical charge balances, compound evaluations, or dual measurement comparisons.

3.9 Corrective Actions

Corrective actions may be required for two major types of problems: analytical/equipment problems and nonconformance with criteria. Analytical and equipment problems may occur during sampling, sample handling, sample preparation, laboratory instrumental analysis, and data review.

Nonconformance with specified criteria and analytical/equipment problems will be documented through a formal corrective action program at the time the problem is identified. The person identifying the problem is responsible for notifying the Project Manager and the USACE Task/Technical Lead. When the problem is analytical in nature, information on these problems will be promptly communicated to the USACE Laboratory Coordinator and the Analytical Laboratory Coordinator. Implementation of corrective action should be confirmed in writing.

Any nonconformance with the established QC procedures in this SAG or an activity-specific WD will be identified and corrected in accordance with this section. The Project Manager or his/her designee will issue an NCR (Figure 3-7) for each nonconforming condition.

Corrective actions will be implemented and documented in the field record book. No staff member should initiate corrective action without prior communication of findings through the proper channels. If corrective actions are deemed insufficient, work may be stopped through a stop-work order issued by the Project Manager and the USACE Task/Technical Lead.

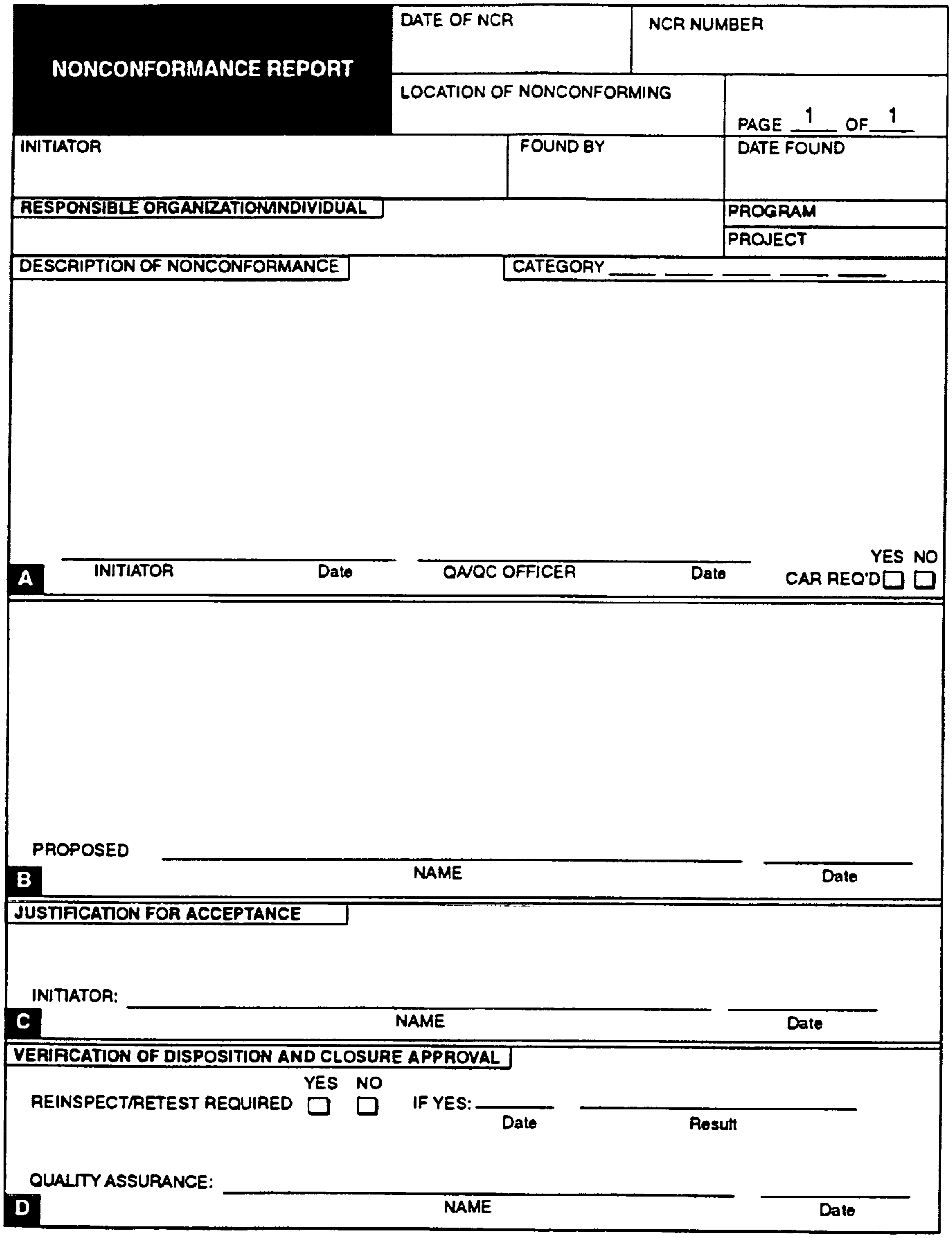
3.9.1 Sample Collection/Field Measurements

Technical staff and project personnel will be responsible for reporting all suspected technical and QA nonconformances or suspected deficiencies of any activity or issued document by reporting the situation to the Project Manager or his/her designee. The Project Manager will be responsible for assessing the suspected problems in consultation with the QA/QC Officer and Laboratory Coordinator to make a decision based on the potential for the situation to impact the quality of the data. When it is determined that the situation warrants a reportable nonconformance and corrective action, then an NCR will be initiated by the Project Manager.

The Project Manager will be responsible for ensuring that corrective actions for nonconformances are initiated by:

- Evaluating all reported nonconformances;
- Controlling additional work on nonconforming items;
- Determining disposition or action to be taken;
- Maintaining a log of nonconformances;
- Reviewing NCRs and corrective actions taken; and
- Ensuring that NCRs are included in the final site documentation project files.

If appropriate, the Project Manager will ensure that no additional work dependent on the nonconforming activity is performed until the corrective actions are completed.



NONCONFORMANCE REPORT

DATE OF NCR

NCR NUMBER

LOCATION OF NONCONFORMING

PAGE 1 OF 1

INITIATOR

FOUND BY

DATE FOUND

RESPONSIBLE ORGANIZATION/INDIVIDUAL

PROGRAM

PROJECT

DESCRIPTION OF NONCONFORMANCE

CATEGORY ____ ____ ____ ____ ____

A INITIATOR Date QA/QC OFFICER Date

CAR REQ'D YES ☐ NO ☐

B PROPOSED ____________ NAME ______ Date

JUSTIFICATION FOR ACCEPTANCE

C INITIATOR: ____________ NAME ______ Date

VERIFICATION OF DISPOSITION AND CLOSURE APPROVAL

REINSPECT/RETEST REQUIRED YES ☐ NO ☐ IF YES: ______ Date ______ Result

D QUALITY ASSURANCE: ____________ NAME ______ Date

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Figure 3-7. Example of a Nonconformance Report

Corrective action for field measurements may include:

- Repeating the measurement to check the error;
- Checking for all proper adjustments for ambient conditions such as temperature;
- Checking the batteries;
- Re-calibrating equipment;
- Checking the calibration;
- Modifying the analytical method including documentation and notification (i.e., standard additions);
- Replacing the instrument or measurement devices; and
- Stopping work (if necessary).

The Project Manager or designee is responsible for all site activities. In this role, the Project Manager may at times be required to adjust the site activities to accommodate activity-specific needs. When it becomes necessary to modify an activity, the responsible person notifies the Project Manager of the anticipated change and implements the necessary changes after obtaining the approval of the Project Manager and the USACE Task/Technical Lead. All such changes will be documented on USACE TDF that should be signed by the initiators and the Project Manager and USACE Task/Technical Lead. The TDF for each document will be numbered serially as required. The TDF should be attached to the file copy of the affected document. The Project Manager must approve the change in writing or verbally before field implementation. If unacceptable, the action taken during the period of deviation will be evaluated in order to determine the significance of any departure from established program practices and action taken.

The Project Manager for the site is responsible for controlling, tracking, and implementing the identified changes. Reports on all changes should be distributed to all affected parties, including the USACE Task/Technical Lead. USACE must be notified whenever program changes in the field are made.

3.9.2 Laboratory Analyses

Each project investigation laboratory QA plan should provide systematic procedures to identify out-of-control situations and corrective actions. Corrective actions must be implemented to resolve problems and restore malfunctioning analytical systems. Laboratory personnel should receive QA training and be made aware that corrective actions are necessary when:

- QC data are outside warning or control windows for precision and accuracy;
- Blanks contain target analytes above acceptable levels and must be investigated;
- Undesirable trends are detected in spike recoveries or RPD between duplicates;
- There are unusual changes in detection limits;
- Deficiencies are detected by internal audits, external audits, or from performance evaluation samples results; and
- Inquiries concerning data quality are received.

Corrective action procedures are often handled at the bench level by the analyst who reviews the preparation or extraction procedure for possible errors and checks the instrument calibration, spike and calibration mixes, instrument sensitivity, and so on. If the problem persists or cannot be identified, the matter is referred to the Laboratory Supervisor, Manager, and/or QA Department for further investigation. Once resolved, full documentation of the corrective action procedure is filed with project records and the Laboratory QA Department, and the information is summarized within case narratives.

Corrective actions may include:

- Reanalyzing the samples, if holding time criteria permit;
- Evaluating blank contaminant sources, elimination of these sources, and reanalysis;
- Modifying the analytical method (i.e., standard additions) with appropriate notification and documentation;
- Resampling and analyzing;
- Evaluating and amending sampling procedures; and
- Accepting data and acknowledging the level of uncertainty.

If resampling is deemed necessary due to laboratory problems, the Project Manager should identify the necessary cost recovery approach to implement the additional sampling effort.

The following corrective action procedures will be required:

- Problems noted during sample receipt will be documented in the appropriate laboratory LOR. The contractor and USACE will be contacted immediately to determine problem resolution. All corrective actions will be thoroughly documented.

- When sample extraction/digestion or analytical holding times are not within method required specifications, the contractor and USACE will be notified immediately to determine problem resolution. All corrective actions will be thoroughly documented.

- All initial and continuing calibration sequences that do not meet method requirements will result in a review of the calibration. When appropriate, re-analysis of the standards or re-analysis of the affected samples back to the previous acceptable calibration check is warranted.

- All appropriate measures will be taken to prepare and clean up samples in an attempt to achieve the practical quantitation limits as stated. When difficulties arise in achieving these limits, the laboratory will notify the contractor and USACE to determine problem resolution. All corrective actions will be thoroughly documented.

- Any dilutions impacting the practical quantitation limits will be documented in case narratives along with revised quantitation limits for those analytes are affected. Analytes detected above the method detection limits, but below the practical quantitation limits, will be reported as estimated values.

- Failure of method-required QC to meet the requirements specified in this project QAPP shall result in review of all affected data. Resulting corrective actions may encompass those identified earlier. The contractor and USACE will be notified as soon as possible to discuss possible corrective actions, particularly when unusual or difficult sample matrices are encountered.

- When calculation and reporting errors are noted within any given data package, reports will be reissued with applicable corrections. Case narratives should clearly state the reasons for reissuance of reports.

3.10 Data Reduction, Validation, and Reporting

3.10.1 Data Reduction

3.10.1.1 Field Measurements and Sample Collection

Raw data from field measurements and sample collection activities will be appropriately recorded in field logbooks. Data to be used in project reports should be reduced and summarized. The methods of data reduction should be documented.

The Project Manager or designee is responsible for data review of all field-generated data. This includes verifying that all field descriptive data are recorded properly, that all field instrument calibration requirements have been met, that all field QC data have met frequency and criteria goals, and that field data are entered accurately in all applicable logbooks and worksheets.

3.10.1.2 Laboratory Services

All samples collected for these investigations should be sent to USACE HTRW CX qualified laboratories. Data reduction, evaluation, and reporting for samples analyzed by a laboratory will be performed according to specifications outlined in the laboratory's QA plan. Laboratory reports should specifically include documentation verifying analytical holding time compliance.

Laboratories will perform in-house analytical data reduction under the direction of the Laboratory QA Manager. The Laboratory QA Manager is responsible for assessing data quality and informing the contractor and USACE of any data that are considered "unacceptable" or require caution on the part of the data user in terms of their reliability. Data will be reduced, evaluated, and reported as described in the laboratory QA plan. Data reduction, review, and reporting by the laboratory will be conducted as follows:

- Raw data are produced by the analyst who has primary responsibility for the correctness and completeness of the data. All data will be generated and reduced following the SAG and activity-specific WD defined methods and implementing laboratory SOP protocols.

- Level 1 technical data review is completed relative to an established set of guidelines by a peer analyst. The review will ensure the completeness and correctness of the data while assuring that all method QC measures have been implemented and were within appropriate criteria.

- Level 2 technical review is completed by the area supervisor or data review specialist. This process reviews the data for attainment of QC criteria as outlined in the established methods and for overall reasonableness. It will ensure that all calibration and QC data are in compliance and check at least 10 percent of the data calculations. This review will document that the data package is complete and ready for reporting and archiving.

- Upon acceptance of the raw data by the area supervisor, the report is generated and sent to the Laboratory Project Manager for Level 3 administrative data review. This review will ensure consistency and compliance with all laboratory instructions, the laboratory QA plan, the project laboratory SOW, this SAG, and the activity-specific WD.

- The Laboratory Project Manager will complete a thorough review of all reports.

- Final reports will be generated and signed by the Laboratory Project Manager.

- Data will then be delivered to the contractor for data validation.

The data review process will include identification of any out-of-control data points and data omissions, as well as interactions with the laboratory to correct data deficiencies. Decisions to repeat sample collection and analyses may be made by the Project Manager based on the extent of the deficiencies and their importance in the overall context of the project. The laboratory will provide flagged data to include such items as: (1) concentration below required detection limit, (2) estimated concentration due to poor spike recovery, and (3) concentration of chemical also found in laboratory blank.

Laboratories will prepare and retain full analytical and QC documentation for the project. Such retained documentation will be both hard (paper) copy and electronic storage media (e.g., magnetic tape) as dictated by the analytical methodologies employed. As needed, laboratories will supply hard copies of the retained information.

Laboratories will provide the following information to USACE and the contractor using appropriate standard forms in each analytical data package submitted:

- Cover sheets listing the samples included in the report and narrative comments describing problems encountered in analysis;
- Tabulated results of inorganic, organic, radionuclide, and miscellaneous parameters identified and quantified;
- Analytical results for QC sample spikes, sample duplicates, initial and continuous calibration verifications of standards and blanks, standard procedural blanks, LCSs, and other deliverables as identified in Section 3.10 of this QAPP;

- Tabulation of instrument detection limits determined in pure water;
- MS/MSD percent recoveries and percent difference (organic methods);
- MS percent recovery (inorganic methods);
- Field duplicate precision, Sample percent moisture; and

- Laboratory replicate precision (inorganic methods).

3.10.2 Data Review, Evaluation and Validation

The FUSRAP Laboratory Coordinator and other data management personnel will perform the review and evaluation of chemical and radiological data, and the validation of chemical and any radiological data not generated from the St. Louis FUSRAP Radiological Laboratory. The St. Louis District Chemist will perform the validation of radiological data generated from the St. Louis FUSRAP Radiological Laboratory.

Data validation is the systematic process of ensuring that the precision and accuracy of the analytical data are adequate for their intended use. Validation shall be performed in accordance with EPA regional or National Functional Guidelines, or project-specific guidelines. General chemical data quality management guidance found in ER-1110-1-263 (USACE, 1998e) may also be used when planning for chemical data management and evaluation. Information gathered during this validation process will be documented with a USACE Data Validation Form (or contractor validation forms containing equivalent documentation), and will be completed and presented with a Quality Control Summary Report (QCSR). Additional details of data review, evaluation and validation are provided in the *Data Management Process for the St. Louis FUSRAP Sites* (SAIC, 1999). Data assessment guidance, to determine the usability of data from HTRW projects, is provided in EM-200-1-6 (USACE, 1997).

One hundred percent of the data generated from all analytical laboratories shall undergo independent data review and evaluation. Data review documents possible effects on the data that result from various QC failures, it does not determine data usability, nor does it include assignment of data qualifier flags. Data evaluation uses the results of the data review to determine the usability of the data. Data evaluation summarizes the potential effects of QA/QC failures on the data, and the District Chemist or District Health Physicist assesses their impact on the attainment of the project-specific DQOs and contract compliance.

Consistent with the data quality requirements, as defined in the DQOs, 10 percent of all project data will be validated and qualified per the outcome of the review. Screening samples do not require validation.

3.10.2.1 Data Validation Approach

A systematic process for data verification and validation will be performed to ensure that the precision and accuracy of the analytical data are adequate for their intended use. The greatest uncertainty in a measurement is often a result of the sampling process and inherent variability in the environmental media rather than the analytical measurement. Therefore, analytical data validation will be performed only to the level necessary to minimize the potential of using false positive or false negative results in the decision-making process (i.e., to ensure accurate identification of detected versus non-detected compounds). This approach is consistent with the DQOs for the project, with the analytical methods, and for determining contaminants of concern and calculating risk.

Samples should be analyzed through implementation of "definitive" analytical methods. "Definitive data" will be reported consistent with the deliverables identified in Section 3.10.4

and shown in Tables 3-6 and 3-7. This report content is consistent with what is understood as an EPA Level III deliverable (data forms including laboratory QC and calibration information). Definitive data should be validated through the review process presented in Section 3.10.2.2. DQOs identified in Section 3.2 and method-specified criteria will be evaluated. The subcontract laboratory will retain comprehensive analytical information.

Validation should be accomplished by comparing the contents of the data packages and QA/QC results to requirements contained in the requested analytical methods. Validation support staff will be responsible for these activities. The protocol for analyte data validation is presented in:

- EPA CLP National Functional Guidelines for Organic Data Review (EPA, 1994b);
- EPA CLP National Functional Guidelines for Inorganic Data Review (EPA, 1994c); and
- Evaluation of Radiochemical Data Usability (DOE, 1997b).

Validation support staff will conduct a systematic review of the data for compliance with the established QC criteria based on the following categories:

- Holding times;
- Blanks;
- LCSs;
- Surrogate recovery (organic methods);
- Internal standards (primarily organic methods);
- Isotopic tracers (radionuclide methods);
- MS/MSD (inorganic methods);
- Inductively coupled plasma (ICP) or atomic absorption QC;
- Calibration;
- Sample reanalysis;
- Secondary dilutions; and
- Laboratory case narrative.

Consistent with the data quality requirements as defined in the DQOs, all project data and associated QC will be evaluated on these categories and qualified as per the outcome of the review. Information gathered during this validation process should be consistent with the information demonstrated by the USACE Data Validation Form (Figure 3-8). Either these forms or contractor validation forms containing equivalent documentation will be completed and presented with the QCSR.

3.10.2.2 Primary Analytical Data Validation Categories

Holding Times

Evaluation of holding times ascertains the validity of results based on the length of time from sample collection to sample preparation or sample analysis or from sample preparation to sample analysis. Verification of sample preservation must be confirmed and accounted for in the evaluation of sample holding times. The evaluation of holding times is essential to establishing sample integrity and representativeness. Concerns regarding physical, chemical, or biochemical alteration of analyte concentrations can be eliminated or qualified through this evaluation.

Blanks

The assessment of blank analyses is performed to determine the existence and magnitude of contamination problems. The criteria for evaluation of blanks apply to any blank associated with the samples, including field, trip, equipment, and method blanks. Contamination during sampling or analysis, if not discovered, results in false-positive data.

Blanks will be evaluated against quantitation limit goals as specified in Table 3-3 unless specified differently in the activity-specific WD. Analytical method blanks should be below these levels. Source water, trip, and equipment rinsate blanks will be evaluated against these levels for most analytes.

Laboratory Control Samples

The LCS serves as a monitor of the overall performance of the analytical process, including sample preparation, for a given set of samples. Evaluation of this standard provides confidence in or allows qualification of results based on a measurement of process control during each sample analysis.

Surrogate Recovery

System monitoring compounds are added to every sample, blank, MS, MSD, and standard. They are used to evaluate extraction, cleanup, and analytical efficiency by measuring recovery on a sample-specific basis. Poor system performance and/or matrix effects as indicated by low surrogate recoveries are one of the most common reasons for data qualification. Evaluation of surrogate recovery is critical to the provision of reliable sample-specific analytical results.

Internal Standards

Internal standards are utilized to evaluate and compensate for sample-specific influences on the analyte quantification. They are evaluated to determine if data require qualification due to excessive variation in acceptable internal standard quantitative or qualitative performance measures. For example, a decrease or increase in internal standard area counts for organics may reflect a change in sensitivity that can be attributed to the sample matrix. Because quantitative determination of analytes is based on the use of internal standards, evaluation is critical to the provision of reliable analytical results.

DATE: ____________________

REVIEWER NAME: ____________________

SIGNATURE: ____________________

TITLE: ____________________

DATA VALIDATION CHECKLIST

PROJECT NAME: ____________________

PROJECT NUMBER: ____________________

SAMPLE ID (NUMBERS): ____________________

SAMPLING TEAM: ____________________

SAMPLE MATRIX: ____________________

ANALYSES PERFORMED: ____________________

CESAS DATA REPORTING LEVEL

FIELD DATA DOCUMENTATION:

FIELD SAMPLING LOGS:	REPORTED		ACCEPTABLE		NOT REQUIRED
	NO	YES	NO	YES	
1. SAMPLING DATES NOTED					
2. SAMPLING TEAM INDICATED					
3. SAMPLE ID TRACEABLE TO LOCATION					
4. SAMPLE LOCATION					
5. SAMPLE DEPTHS FOR SOILS					
6. COLLECTION TECHNIQUE (BAILER, PUMP, ETC.)					
7. SAMPLE TYPE (GRAB, COMPOSITE)					
8. SAMPLE CONTAINER					
9. SAMPLE PRESERVATION					
10. CHAIN OF CUSTODY FORM COMPLETED					
11. REQUIRED ANALYTICAL METHODS					
12. FIELD WATER AND SOIL SAMPLE LOGS					
13. NUMBER OF QA & QC SAMPLES COLLECTED					
14. FIELD EQUIPMENT CALIBRATION					
15. FIELD EQUIPMENT DECONTAMINATION					
16. SAMPLE SHIPPING					

COMMENTS:

Figure 3-8. USACE Data Validation Form

Page 1 of 2

LABORATORY DATA VALIDATION:	REPORTED		ACCEPTABLE		NOT REQUIRED
	NO	YES	NO	YES	
1. SAMPLING RESULTS					
2. PARAMETERS ANALYZED					
3. ANALYTICAL METHOD					
4. SAMPLE RECEIPT DATE					
5. SAMPLE PREPARATION DATE					
6. HOLDING TIMES					
7. CALIBRATION					
8. MS/MSD RPD OR SAMPLE LD RPD					
9. SURROGATE SPIKE RESULTS					
10. BLANKS					
A. RINSATES					
B. FIELD BLANKS					
C. TRIP BLANKS					
11. SAMPLE pH					
12. SAMPLE TEMPERATURE					
13. DETECTION LIMITS					
14. QC DATA					
A. INORGANIC					
B. ORGANIC					

ANALYTE: ______________________

FLAG: ______________________

REMARKS: ______________________

____

____

____

OVERALL COMMENTS: ______________________

____

____

DEFINITIONS:

U	Analyte not detected
J	Analyte identified, concentration is estimated value
UJ	Analyte not detected above estimated detection limits
B	Blank contaminated
R	Rejected value, presence or absence of analyte cannot be verified
UR	Rejected detection limits
MS	Matrix Spike
MSD	Matrix Spike Duplicate
RPD	Relative Percent Difference
LD	Laboratory Duplicate

Page 2 of 2

Figure 3-8. USACE Data Validation Form (continued)

Isotopic Tracers

Isotopic tracers are utilized to evaluate and compensate for sample-specific influences and preparation aberrations on the radionuclide quantification. They are evaluated to determine if data require qualification due to excessive variation in acceptable tracer quantitative or qualitative performance measures. For example, a decrease or increase in tracer recovery for a given isotope may reflect a change in sensitivity that can be attributed to the sample matrix or preparation process. Because quantitative determination of many radionuclides is based on the use of tracers, evaluation is critical to the provision of reliable analytical results.

Furnace Atomic Absorption QC

Duplicate injections and furnace post-digestion spikes are evaluated to establish precision and accuracy of individual analytical determinations. Because of the nature of the furnace atomic absorption technique and because of the detailed decision tree and analysis scheme required for quantitation of the elements, evaluation of the QC is critical to ensuring reliable analytical results.

Calibration

The purpose of initial and continuing calibration verification analyses is to verify the linear dynamic range and stability of instrument response. Relative instrument response is used to quantitate the analyte results. If the relative response factor is outside acceptable limits, the data quantification is uncertain and requires appropriate qualification.

Sample Reanalysis

When instrument performance-monitoring standards indicate that an analysis is out of control, the laboratory is required to reanalyze the sample. If the reanalysis does not solve the problem (i.e., surrogate compound recoveries are outside the limits for both analyses), the laboratory is required to submit data from both analyses. An independent review is required to determine which is the appropriate sample result.

Secondary Dilutions

When the concentration of any analyte in any sample exceeds the initial calibration range, a new aliquot of that sample must be diluted and reanalyzed. The laboratory is required to report data from both analyses. When this occurs, an independent review of the data is required to determine the appropriate results to be used for that sample. An evaluation of each analyte exceeding the calibration range must be made, including a review of the dilution analysis performed. Results chosen in this situation may be a combination of both the original results (i.e., analytes within initial calibration range) and the secondary dilution results.

Laboratory Case Narratives

Analytical laboratory case narratives are reviewed for specific information concerning the analytical process. This information is used to direct the data validator to potential problems with the data.

3.10.3 Project Analytical Data Set

Analytical data for each project will be verified electronically and validated by qualified chemists. Flags signifying the usability of data will be noted and entered into an analytical database. Deficiencies in data deliverables should be corrected through direct communication with the field or laboratory, generating immediate response and resolution. All significant data discrepancies noted during the validation process should be documented through NCRs, which are sent to the laboratory for clarification and correction.

Decisions to repeat sample collection and analyses may be made by the USACE Task/Technical Lead or the Project Manager based on the extent of the deficiencies and their importance in the overall context of the project.

All data generated for investigations will be computerized in a format organized to facilitate data review and evaluation. The computerized data set will include data flags in accordance with the above-referenced protocols as well as additional comments of the Data Review Team. The associated data flags will include such items as: (1) estimated concentration below-required reporting limit; (2) estimated concentration due to poor calibration, internal standard, or surrogate recoveries; (3) estimated concentration due to poor spike recovery; and (4) estimated concentration of a chemical that was also determined in the laboratory trip and/or rinsate blank.

Data assessment should be accomplished by the joint efforts of the data validator, the data assessor, and the Project Manager. Data assessment by data management will be based on the criteria that the sample was properly collected and handled according to the SAG, activity-specific WD, Sections 3.3 and 3.4 of the QAPP, and EM-200-1-6 guidance (USACE, 1997). An evaluation of data accuracy, precision, sensitivity and completeness, based on criteria in Section 3.8, will be performed by a data assessor and presented in the QCSR. This data quality assessment should indicate that data are: (1) usable as a quantitative concentration, (2) usable with caution as an estimated concentration, or (3) unusable due to out-of-control QC results.

Project investigation data sets will be available for controlled access by the Project Manager and authorized personnel. Each data set will be incorporated into investigation reports as required.

3.10.4 Data Reporting

Laboratories will prepare and submit analytical and QC data reports to USACE and the contractor in accordance with the requirements of this SAG and the activity-specific WD, including data forms listed in Table 3-6. An electronic copy of data will be provided in an ASCII data file, CLP format, or other compatible format for entry into the database. An acceptable configuration is presented in Table 3-7 with all QA/QC sample data being provided in a companion ASCII file.

The laboratory will be required to confirm sample receipt and log-in information. The laboratory should return a copy of the completed chain-of-custody and confirmation of the laboratory's analytical log-in to the contractor within 24 hours of sample receipt.

Table 3-6. Summary of Analytical Hard-Copy Data Deliverables

Method Requirements	Deliverables
Requirements for all methods:	
- Holding time information and methods requested	Signed chain-of-custody forms
- Discussion of laboratory analysis, including any laboratory problems	Case narratives
Organics: GC/MS analysis	
- Sample results, including TICs	CLP Form 1 or equivalent
- Surrogate recoveries	CLP Form 2 or equivalent
- Matrix spike/spike duplicate data	CLP Form 3 or equivalent
- Method blank data	CLP Form 4 or equivalent
- GC/MS tune	CLP Form 5 or equivalent
- GC/MS initial calibration data	CLP Form 6 or equivalent
- GC/MS continuing calibration data	CLP Form 7 or equivalent
- GC/MS internal standard area data	CLP Form 8 or equivalent
Organics: GC analysis	
- Sample results	CLP Form 1 or equivalent
- Surrogate recoveries	CLP Form 2 or equivalent
- Matrix spike/spike duplicate data	CLP Form 3 or equivalent
- Method blank data	CLP Form 4 or equivalent
- Initial calibration data	CLP Form 6 or equivalent
- If calibration factors are used	A form listing each analyte, the concentration of each standard, the relative calibration factor, the mean calibration factor, and %RSD
	Calibration curve and correlation coefficient
- Calibration curve if used	CLP Form 9 or equivalent
- Continuing calibration data	CLP Form 10 or equivalent
- Positive identification (second column confirmation)	
Metals	
- Sample results	CLP Form 1 or equivalent
- Initial and continuing calibration	CLP Form 2 or equivalent, dates of analyses and calibration curve, and the correlation coefficient factor
- Method blank	CLP Form 3 or equivalent and dates of analyses
- ICP interference check sample	CLP Form 4 or equivalent and dates of analyses
- Spike sample recovery	CLP Form 5A or equivalent
- Postdigestion spike sample recovery for ICP metals	CLP Form 5B or equivalent
- Postdigestion spike for GFAA	CLP Form 5B or equivalent
- Duplicates	CLP Form 6 or equivalent
- LCS	CLP Form 7 or equivalent that includes acceptable range or window
	CLP Form 8 or equivalent
- Standard additions (when implemented)	CLP Form 13 or equivalent
- Holding times	CLP Form 14 or equivalent
- Run log	
Wet Chemistry	
- Sample results	Report result
- Matrix spike recovery	%Recovery
- Matrix spike duplicate or duplicate	%Recovery and %RPD
- Method blank	Report results
- Initial calibration	Calibration curve and correlation coefficient
- Continuing calibration check	Recovery and % difference
- LCS	LCS result and control criteria
- Run log	Copy of run log
Radiochemical Analysis	
- Sample results	Report results
- Initial calibration	Efficiency determination
- Efficiency check	%Difference from calibration
- Background determinations	Report results
- Spike recover results	Report results
- Internal standard results (tracers or carriers)	Report results
- Duplicate results	Spike added and %Recovery
- Self-absorption factor (α,β)	Standard added and %Recovery
- Cross-talk factor (α,β)	Report results and %RPD
- LCS	Report factors
- Run log	Report factors and control criteria
	LCS results and control criteria
	Copy of run log

CLP	contract laboratory program	ICP	inductively coupled plasma	RPD	relative percent difference
GC	gas chromatography	LCS	laboratory control sample	RSD	relative standard deviation
GFAA	graphite furnace atomic absorption	MS	mass spectrometry	TIC	tentatively identified compound

Table 3-7. Standard Electronic Data Deliverables

Column Position	Length	Field Description
Header Record		
1-20	20	SAIC Project Number
21-28	8	Data Submission Date (MM/DD/YY)
29-33	6	Number of Records (Rows) in the file including header and terminating records
34-74	40	Submitting Laboratory Name
Detail Record		
1-20	20	SAIC Sample Identification Number
21-28	8	Date of Sample Collection (MM/DD/YY)
29-33	5	Time of Sample Collection (HH:MM military format)
34-48	15	Laboratory Analytical Batch/Sample Delivery Group (SDG) Number
49-56	8	Sample Matrix
57-76	20	Laboratory Sample Identification Number
77-84	8	Sample Extraction/Preparation Date (MM/DD/YY)
85-92	8	Sample Analysis Date (MM/DD/YY)
93-97	5	Sample Analysis Time (HH:MM military format)
98-100	3	Analysis/Result Type – This field is used to designate the type of analysis performed. Valid values are as follows: REG = Regular Sample Analysis DUP = Laboratory Duplicate Analysis DIL = Secondary Dilution Analysis REn = Re-analysis where "n" is a sequential number
101-112	12	Chemical Abstract Services (CAS) Number
113-142	30	Analysis Name
143-157	15	Analysis Method (Method numbers shall be the EPA, SW-846, NIOSH, etc. method number)
158-167	10	Result (Report detection limit if not detected)
168-177	10	Radiological Counting Error
178-182	5	Result Qualifier (U, J, etc.)
183-190	8	Unit of measure
191-200	10	Instrument Detection Limit
201-205	5	Percent Solids (Report "0" for water matrices)
206-300	5	Sample Weight/Volume
301-302	2	Sample Weight/Volume Units
303-307	5	Dilution
Termination Record		
1-3	3	$$$

Electronic deliverables must have file structure defined in this table. The deliverable file may be either an ASCII text file, a dBASE compatible file (.DBF file extension), or an Excel spread sheet file (.XLS file extension). All fields must be presented. Fields that are not applicable for the reported method shall be reported as blank.

The subcontract analytical laboratory will prepare and retain full analytical and QC documentation. Such retained documentation will include all hard copies and other storage media (e.g., magnetic tape). As needed, the subcontract analytical laboratory will make available all retained analytical data information.

3.11 Preventive Maintenance Procedures

3.11.1 Field Instruments and Equipment

The field equipment for each project may include temperature probes; pH meters; conductivity meters; alpha/beta and gamma survey meters; organic vapor detectors (FID or PID); and geophysical equipment. Specific preventative maintenance procedures to be followed for field equipment are those recommended by the manufacturers. These procedures are included in the technical procedures governing the use of these instruments.

Field instruments should be checked and/or calibrated before they are shipped or carried to the field. Each field instrument will be checked daily against a traceable standard or reference with a known value to ensure that the instrument is in proper calibration. Instruments found to be out of calibration will be re-calibrated before use in the field. If an instrument cannot be calibrated, it should be returned to the supplier or manufacturer for re-calibration, and a backup instrument should be used in its place. Calibration checks and calibrations will be documented on the Field Meter/Calibration Log Sheets in the M&TE logbook. Any maintenance conducted on field equipment must also be documented in the M&TE logbook.

Critical spare parts such as tapes, papers, pH probes, electrodes, and batteries should be kept on-site to minimize downtime of malfunctioning instruments. Backup instruments and equipment should be available on-site or within 1-day shipment to avoid delays in the field schedules.

3.11.2 Laboratory Instruments

As part of their QA/QC Program, a routine preventive maintenance program will be conducted by all investigation-associated laboratories to minimize the occurrence of instrument failure and other system malfunctions. All laboratory instruments will be maintained in accordance with manufacturers' specifications and the requirements of the specific method employed. This maintenance will be carried out on a regular, scheduled basis and will be documented in the laboratory instrument service logbook for each instrument. Emergency repair or scheduled manufacturer's maintenance will be provided under a repair and maintenance contract with factory representatives. An adequate supply of spare parts utilized for routine maintenance will be maintained for each test instrument to avoid unnecessary delays.

3.12 Performance and System Audits

Performance and system audits of both field and laboratory activities will be conducted to verify that sampling and analysis activities are performed in accordance with the procedures established in the SAG and activity-specific WD. Audits of laboratory activities should include both internal and external audits.

3.12.1 Field Assessments

Internal assessments (audit or surveillance) of field activities (sampling and measurements) will be conducted by the QA/QC Officer (or designee). Assessments should include examination of field sampling records, field instrument operating records, sample collection, handling and packaging in compliance with the established procedures, maintenance of QA procedures and chain-of-custody. These assessments will occur at the onset of the project to verify that all established procedures are followed (systems audit).

Performance assessments should follow to ensure that deficiencies have been corrected and to verify that QA practices/procedures are being maintained throughout the duration of the project work effort. These assessments will involve reviewing field measurement records, instrumentation calibration records, and sample documentation.

External audits may be conducted at the discretion of USACE, EPA Region VII, or the State of Missouri.

3.12.2 Laboratory Audits

The USACE HTRW CX conducts on-site audits and validates laboratories on a regular basis. These USACE independent on-site systems audits, in conjunction with performance evaluation samples (performance audits), qualify laboratories to perform USACE environmental analysis every 18 months.

These system audits include examining laboratory documentation of sample receiving, sample log-in, sample storage, chain-of-custody procedures, sample preparation and analysis, and instrument operating records. Performance audits consist of sending performance evaluation samples to USACE laboratories for ongoing assessment of laboratory precision and accuracy. The analytical results of the analysis of performance evaluation samples are evaluated by USACE HTRW CX to ensure that laboratories maintain an acceptable performance.

Internal performance and system audits of laboratories will be conducted by the Laboratory QA Manager as directed in the laboratory QA plan. These system audits will include examination of laboratory documentation of sample receiving, sample log-in, sample storage, chain-of-custody procedures, sample preparation and analysis, and instrument operating records against the requirements of the laboratory's SOPs. Internal performance audits are also conducted on a regular basis. Single-blind performance samples are prepared and submitted along with project samples to the laboratory for analysis. The Laboratory QA Manager will evaluate the analytical results of these single-blind performance samples to ensure that the laboratory maintains acceptable performance.

The contractor is not contracted to perform laboratory audits; however, additional audits of laboratories may be planned and budgeted within specific USACE task scopes. These project-specific laboratory performance review audits would be conducted by the contractor only at the direction of and in conjunction with USACE, when requested.

External audits may be conducted in conjunction with or at the direction of the EPA Region or the State of Missouri regulatory agency.

3.13 QA Reports to Management

3.13.1 Daily Quality Control Reports

During the field investigation activities performed for this project, the contractor will prepare DQCRs (or equivalent documentation), that should be signed and dated by the CQC Representative. An example of the DQCR format to be used is illustrated in Figure 3-9. These reports should be submitted to the USACE Task/Technical Lead on a weekly basis. The contents of each DQCR will include a summary of activities performed at the project site, weather information, results of CQC activities performed including field instrument calibrations, departures from the approved activity-specific WD problems encountered during field activities, and any instructions received from government personnel. Any deviations that may affect the project data quality objectives will be immediately conveyed to the USACE Task/Technical Lead.

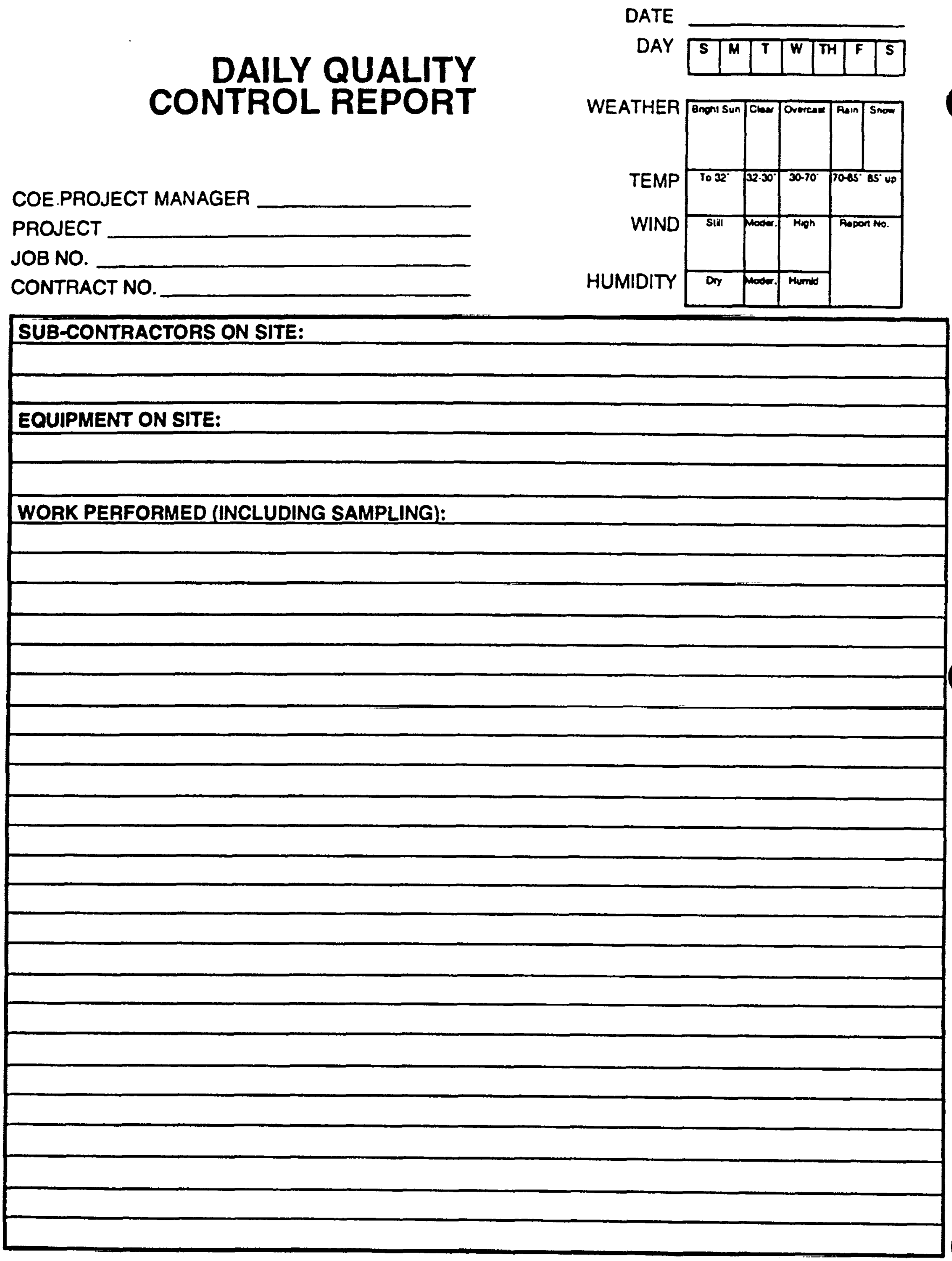
3.13.2 Quality Assurance Reports

Each laboratory will provide LORs and analytical QC summary statements (case narratives) with each data package. All chain-of-custody forms will be compared with samples received by the laboratory, and an LOR will be prepared and sent to the contractor describing any differences in the chain-of-custody forms and the sample labels or tags. All deviations, such as broken or otherwise damaged containers, will be identified on the receiving report. This report will be forwarded to the contractor within 24 hours of sample receipt and will include the following: a signed copy of the chain-of-custody form; itemized contractor sample numbers; laboratory sample numbers; cooler temperature upon receipt; and itemization of analyses to be performed.

Summary QC statements will accompany analytical results as they are reported by the laboratory in the form of case narratives for each sample delivery group.

Any departures from approved plans must receive prior approval from the USACE Task/Technical Lead and will be documented with USACE TDFs. These TDFs will be incorporated into the project evidence file.

The contractor will maintain custody of the project evidence file and will maintain the contents of files for this project, including all relevant records, reports, logs, field logbooks, pictures, subcontractor reports, correspondence, and chain-of-custody forms, until this information is transferred to the USACE Task/Technical Lead. These files will be stored under custody of the Project Manager. Analytical laboratories will retain all original analytical raw data information (both hard copy and electronic) in a secure, limited access area and under custody of the Laboratory Project Manager.



DATE ____________

DAY

S	M	T	W	TH	F	S

DAILY QUALITY CONTROL REPORT

WEATHER	Bright Sun	Clear	Overcast	Rain	Snow
TEMP	To 32°	32-30°	30-70°	70-85°	85° up
WIND	Still	Moder.	High	Report No.	
HUMIDITY	Dry	Moder.	Humid		

COE PROJECT MANAGER ____________

PROJECT ____________

JOB NO. ____________

CONTRACT NO. ____________

SUB-CONTRACTORS ON SITE:

EQUIPMENT ON SITE:

WORK PERFORMED (INCLUDING SAMPLING):

98-025MS/080298

Figure 3-9. Example of the Daily Quality Control Report

(Continuation Sheet)

PROJECT ______________________ REPORT NO. ______________________

JOB NO. ______________________ DATE: ______________________

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

PROBLEMS ENCOUNTERED/CORRECTION ACTION TAKEN:

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

____
(Signature and date)

QA Check by: ______________________
(Signature and date)

98-025MS/080298

Figure 3-9. Example of the Daily Quality Control Report (continued)

3.13.3 Quality Control Summary Reports

At the conclusion of field investigation activities and laboratory analysis, the contractor (or validation subcontractor), in addition to any review conducted by the laboratory, will perform its own validation of the submitted data. This activity will include assignment of flags to data, documentation of the reason(s) for the assignments, and description of any other data discrepancies. The contractor will then prepare a QCSR, which should be included as an appendix to the final report. This report should be submitted to the USACE Task/Technical Lead as determined by the project schedule. The contents of the QCSR should include data validation documentation and discussion of all data that may have been compromised or influenced by aberrations in the sampling and analytical processes. Both field and laboratory QC activities will be summarized, and all DQCR information will be consolidated. Problems encountered, corrective actions taken, and their impact on project DQOs will be determined.

The following are examples of elements to be included in the QCSR as appropriate:

- Laboratory QC evaluation and summary of the data quality for each analytical type and matrix. Part of the accuracy, precision, and sensitivity summarized in the data quality assessment;
- Field QC evaluation and summary of data quality relative to data usability. Part of the accuracy, precision, and sensitivity summarized in the data quality assessment;
- Overall data assessment and usability evaluation;
- DQCR consolidation and summary; and
- Summary of lessons learned during project implementation.

Specific elements to be evaluated within the QCSR include the following:

- Sample results;
- Field and laboratory blank results;
- Laboratory control sample percent recovery (method dependent);
- Sample matrix spike percent recovery (method dependent);
- MS/MSD or sample duplicate RPD (method dependent);
- Analytical holding times; and
- Surrogate recovery, when appropriate.

An example of the format that should be used by the contractor for preparation of the project QCSR is presented on Figure 3-10.

QUALITY CONTROL SUMMARY REPORT

1. Introduction

    1.1 Project Description
    1.2 Project Objectives
    1.3 Project Implementation
    1.4 Purpose of this Report

2. Quality Assurance Program

    2.1 Monthly Progress Reports
    2.2 Daily Quality Control Reports (DQCRs)
    2.3 Laboratory "Definitive" Level Data Reporting

3. Data Validation

    3.1 Field Data Validation
    3.2 Laboratory Data Validation
    3.3 Definition of Data Qualifiers (Flags)
    3.4 Data Acceptability

4. Data Evaluation

    4.1 Accuracy
        - Metals
        - Volatile Organic Compounds
        - Total Petroleum Hydrocarbon
        - etc.

    4.2 Precision
        - Laboratory Precision
        - Field Precision

    4.3 Sensitivity
    4.4 Representativeness and Comparability
    4.5 Completeness

5. Data Quality Assessment Summary

6. References

Figure 3-10. Quality Control Summary Report Format

4.0 DATA MANAGEMENT PROGRAM PLAN (DMPP)

4.1 Introduction

This section represents the overall data management program to be implemented for the SLS. The DMPP identifies required data documentation materials and procedures, as well as project file requirements. The DMPP also provides the reporting requirements for presenting raw analytical data. The *Data Management Process for the St. Louis FUSRAP Sites* (SAIC, 1999) has been developed to facilitate the proper and efficient flow of FUSRAP analytical laboratory data, and to ensure the validity and accessibility of data, from field collection and processing by the analytical laboratories, to those involved in the evaluation and decision making phase of the project. Contractors should also consult this document for details of the data management process when preparing for field sampling.

The characterization activities for these sites may produce a large amount of information. The information collected is critical for several reasons. All data will be maintained in electronic files (e.g., on a web site). The primary data management resource will be a relational database accessible to all data users identified as the St. Louis District Environmental Information Management System (SLDEIMS) and the St. Louis District FUSRAP web site. The St. Louis District FUSRAP web site contains an access pathway to the SLDEIMS, related program information, and other basic features. Data should be made accessible to all data users. The information collected may provide the foundation for determining the nature and extent of contamination at the site, for assessing the risks associated with potential contaminants of concern at the site, or for evaluating completed or potential remedial actions. This section describes the data acquisition, management, and analysis requirements.

Project activities may generate data, including sample locations, measurements of field parameters, and results of sample analyses and data reviews. Important records regarding the collection and analysis of the samples and data may also be generated. The data management process requires the proper flow of data from field collection and processing by the analytical laboratory to those involved in the project evaluation and decision making. This DMPP will ensure the validity and accessibility of data to support environmental data analysis and the evaluation of corrective measures.

4.2 Investigation Data

4.2.1 Data Types

Data acquisition activities associated with site characterizations fall into ten broad categories:

- Existing historical information, including photographs and the results from any previous characterization activities at the site;
- Mapping data (including survey data from surveying crews);
- Radiation walkover data;
- Nonintrusive geophysical data;

- Discrete sample results;
- Inorganic and organic screening data;
- Secondary borehole information;
- Gamma exposure measurement data;
- In-situ gamma spectroscopy data; and
- Critical project records.

4.2.1.1 Historical Information

Significant historical information exists for these sites. This information is included in reports documenting past investigations and discrete soil and water analytical results. Most of the analytical results exist in electronic format. The contractor will work with St. Louis USACE, when tasked to do so, to acquire historical data and supporting documents from previous FUSRAP contractors.

4.2.1.2 Mapping Data

Mapping data will be collected during the course of the program. These data may be input into the geographical database along with previously created mapping data. The primary issue associated with mapping data is the issue of ensuring that the various data sets that include spatial location information are consistent relative to each other.

The base coordinate system for the characterization work is Missouri State Plane East (NAD83). All data produced by this characterization effort will be delivered in Missouri State Plane East (NAD83). Elevation data (e.g., ground surface elevations) will be in ft amsl. Depth data (e.g., depth to water surface measurements or depth to samples) will be in ft below a known elevation reference point.

Survey monuments will be established at key locations across the site to facilitate the establishment of local grids and the implementation of spatial accuracy QA/QC techniques. These monuments may be based on established site features (e.g., building corners, large rocks, and trees) or may be introduced. All monuments will be appropriately marked in the field so that they are readily identifiable, will be tagged with their name and Missouri State Plane East (NAD83) location, and will have their positions in Missouri State Plane East (NAD83) recorded electronically. The subcontractor responsible for the civil survey should provide the project with a hard copy report and an electronic copy of the civil survey.

In certain instances (e.g., non-intrusive geophysical surveys and gamma walkover surveys), it may be advantageous to work with local coordinate systems. In the event that local coordinate systems are used, these local coordinate systems will be tied to at least three established monuments and the final data deliverables will be transformed into Missouri State Plane East (NAD83) requirement.

The base level of accuracy for all mapping work at the site is 3 cm (0.1 ft) for horizontal coordinates and 3 cm (0.1 ft) for general vertical measurements. The measuring point (top of inner casing) of ground-water wells will be surveyed to an accuracy of 3 mm (0.01 ft). If the methodologies used to determine locations cannot guarantee a locational error of less than 3 cm (0.1 ft) horizontally or 3 cm (0.1 ft) vertically, these data should be accompanied by an estimate of the maximum and average error expected from the methodology used to generate the data. Examples of methodologies likely to be used at the site that fall into this category are GPS, hand-held survey instruments, and chaining techniques. In the case of all data sets collected for the site that involve spatial coordinates, data set-specific QA/QC techniques will be employed that can identify and eliminate egregious locational errors. Examples of these techniques include visual reviews of mapped data, the use of monument recovery as QA/QC controls, and the use of survey closure techniques.

4.2.1.3 Radiation Walkover Data

Radiation walkover data is typically collected during the second stage of characterization effort, and is also employed during verification. Radiation walkover data may be generated by using a combination of GWS and GPS. Different gamma sensors may be deployed depending on the nuclides to be detected.

The GWS/GPS system used for the site shall be coordinated with and approved by USACE. Some systems may include both real time and post processing capabilities. Real time processing is used to assist in the identification of anomalies that require further investigation or description and for verifying positional control. Post processing is used for error correction and delivering the required electronic deliverables in Missouri State Plane East (NAD83). The contractor collecting the GWS/GPS will maintain field notebooks in which any comments pertaining to GWS/GPS data collection will be entered. GWS/GPS data will be delivered from the contractor with coordinates in Missouri State Plane East (NAD83). To facilitate the review of GWS/GPS sensor data quality, control points will be established and surveyed at the required frequency stated in the WD for that specific survey.

GWS/GPS data files will be checked for positional accuracy by mapping the data and evaluating visually for completeness and plausibility of sensor results. After this initial QA/QC screen, the data files will be available for general dissemination. In addition, a GWS/GPS tracking table will be maintained to document the collection of GWS/GPS data.

4.2.1.4 Non-intrusive Geophysical Data

Nonintrusive geophysical data may be collected at a site to assist in determining the presence or absence of subsurface fill and to assist in mapping buried conductive materials and utilities to support intrusive sampling. Raw nonintrusive geophysical data collected by the contractor will be delivered in ASCII file format in Missouri State Plane East (NAD83). Each data file should include at least three data points that correspond to known monuments at the site. Data files delivered by the contractor will be mapped and checked visually for locational errors. In addition, the contractor should also deliver digital images of graphical interpretation for each data file and an electronic version of the report in standard word processing format (e.g., MS Word). These may also be posted to the web site. Finally, a nonintrusive geophysical data tracking table may be maintained on the web site that identifies each of the areas targeted for nonintrusive surveys, the types of surveys planned for those areas, when the surveys were completed, and when the data became available.

4.2.1.5 Discrete Sample Results

Discrete samples may be collected for analysis in various stages of sampling activities. The primary data management resource for discrete sample information will be a relational database named the SLDEIMS. The types of data to be stored in the SLDEIMS include: (1) sample planning information to be used for pre-populating SLDEIMS and generating sample labels and chain-of-custody documentation in the field; (2) sampling station information; (3) sample descriptions; (4) field screening results associated with samples; and (5) analytical results associated with samples.

Pre-population of SLDEIMS with sampling stations/sample identification and the generation of sampling labels and chain-of-custody records will take place at the site or a contractor office. In addition, the submittal of field screening results to SLDEIMS will be done by staff at the site. In the case of on-site laboratory and/or field screening techniques, standard electronic deliverable formats will be negotiated with the contractors responsible for data generation.

All handling of off-site laboratory results will be completed by the contractor following project procedures. Summary data files from selected SLDEIMS tables should be generated daily and made available (as required) to data users.

Locational information for sampling stations will be estimated from civil surveys and base maps. The maximum locational error expected for these is ±50.8 cm (±1.667 foot). In the event that locational errors are thought to exceed this maximum, the estimated error will be noted. Sampling station locational data will be mapped and visually inspected for gross locational errors.

A discrete sample-tracking table should be maintained. This table will identify, at a minimum, all anticipated samples to be collected, the sampling stations, the analyses performed, the dates these were completed, and the date the information became available within SLDEIMS. Further details of sample planning are provided in the *Data Management Process for the St. Louis FUSRAP Sites* (SAIC, 1999).

4.2.1.6 Secondary Borehole Information

Secondary borehole information includes many types of data that are generated during the course of completing soil borings, temporary well points, and monitoring wells. It can include stratigraphic information/soil classification data, depth-to-water surface data, down-hole screening results (i.e., gamma surveys and resistivity measurements), and notes recorded by field staff at the time of bore completion. These data typically are hand-entered in field notebooks during the completion of the borehole.

These field notebooks will be maintained in a logical and reasonable manner. All data collected in the field logbooks (e.g., screening results, depth-to-water surface data, soils information) may be entered directly into an appropriate SLDEIMS table. These data may be used for archiving and dissemination purposes.

4.2.1.7 Gamma Exposure Measurement Data

Limited gamma exposure measurement data may be collected from locations identified in the activity-specific WD prior to the commencement of intrusive field sampling activities. The results from these data may be entered into the appropriate SLDEIMS data table and made available to the investigating team. Maps indicating the locations where the measurements were taken will also be provided. Locations will be provided in Missouri State Plane East (NAD83).

4.2.1.8 In-Situ Gamma Spectroscopy Data

In-situ gamma spectroscopy with an HPGe crystal may be used to provide real-time in-situ estimates of isotope-specific activity levels at the site. Coordinates for the locations of the HPGe "shots" will be determined using differential GPS. Results from the measurements will be recorded in field notebooks. At the end of each day, these should be entered into electronic format and uploaded into SLDEIMS. HPGe data collection may be tracked using the web-based progress-tracking table developed for discrete samples.

4.2.1.9 Critical Project Records

Critical project records such as survey reports, chain-of-custody forms, laboratory data packages, and validation results will be maintained in accordance with Section 4.4.8.

4.2.2 Key Identifiers

The key identifiers for project sampling data will be the sample location/station and a unique sample identification number. All samples should be assigned an area and station to identify the specific point where the field measurements or samples were collected. Descriptions, geographic coordinates, and elevations should be obtained for these sampling stations.

Unique sample numbers are derived from the location, sampling station within the location, sample medium, and sample type, plus a sequential number. Field duplicates represent a separate sample type, and distinct depths receive different sequential numbers so no duplication of sample numbers will occur. The sample identification should appear on the sample collection log sheet, sample label, chain-of-custody form, and on any correspondence related to the sample. Additional information regarding sample identification is presented in the SAG and activity-specific WD.

Measurements not associated with physical samples (walkover surveys) should be identified by the coordinates of the measurement location Missouri State Plane East (NAD83) and by the date and time of measurement.

4.3 Data Management System

The data management system facilitates the information flow by providing a means of tracking, organizing, reporting, and archiving data and information. The system has three primary components:

- A multidisciplinary team of data management professionals;

- A process model that integrates activities relevant to ensuring that data are complete, consistent, and fully qualified, and minimizes the uncertainties associated with the data, data products, or interpretations of results; and
- A standardized database structure to support the collection, management, analysis, and presentation of site characterization data.

To facilitate management of the data collected for each investigation, the specific WD should include a table, such as Table 4-1, which identifies each data type, data source, location, and responsible person. Further details of data management planning are provided in the *Data Management Process for the St. Louis FUSRAP Sites* (SAIC, 1999).

Table 4-1. Example of a Data Matrix

Data Type	Data Source	Location	Responsibility*

* Person managing the Formerly Utilized Sites Remedial Action Program.

4.4 Data Management and Tracking Process

To meet the regulatory requirements for the acquisition of technically sound and legally admissible data, a traceable audit trail will be established from the development of the project work plan through the archiving of information and data. Each step or variation of the sampling and analytical process should be documented. Standardized formats for electronic transfer and reporting will be used. To meet this requirement, the following data management process will be followed throughout the collection, management, storage, analysis, and presentation of the site environmental data.

4.4.1 Sampling and Analysis Planning

Guidelines for the collection of field and laboratory quality control samples are detailed in this SAG, the QAPP, the activity-specific WD, and the *Data Management Process for the St. Louis FUSRAP Sites* (SAIC, 1999). These documents together specify all applicable sampling and analytical data that should be entered into the database.

The interface with the analytical laboratory is crucial to achieve the goal of collecting and recording technically sound data. Based upon the laboratory data quality objectives presented in the SAG and the activity-specific WD, the laboratory statement of work details analytical methods, validation criteria, deliverables, and deliverable formats required of the analytical laboratory. The analytical laboratories to be contracted for chemical and geotechnical testing must be approved by USACE.

Prior to initiating fieldwork, the SLDEIMS should be populated with sample locations, sample numbers, analytical parameters and detection limits, and associated sampling and laboratory information based on the requirements of the SAG. A report of all planned samples will be generated for review by the FOM. After approval of this report, the data coordinator will generate field sampling forms including preprinted sample information, bind and number the logbooks, and print and organize the required sample labels. This process will increase the accuracy of the final database and minimize the amount of information samplers must record in the field.

4.4.2 Field Sample Collection and Measurement

Prior to beginning field sampling, field personnel will be trained as necessary and participate in a project-specific readiness review. These activities ensure that standard procedures will be followed in sample collection and in completing field logbooks, chain-of-custody forms, labels, and custody seals. Documentation of training and readiness is submitted to the project file.

The master field investigation document will be site field logbooks. The primary purpose of these documents is to record each day's field activities; personnel on each sampling team; and any administrative occurrences, conditions, or activities that may have affected the fieldwork or data quality of any environmental samples for any given day.

Each field sampling team will have a field logbook in which it will record data collected in the field. Guidance for documenting specific types of field sampling activities in field logbooks are provided in Appendix C of EM-200-1-3 (USACE, 1994c). To the extent possible, preprinted field logbook sheets should be generated from the data management system. If preprinted logbook sheets are not used for a given sample, required information will be recorded manually. As samples are collected in the field, the field sampling team members will complete the logbooks with sample collection data and required field measurements as specified in this SAG and the activity-specific WD. Standardized reporting formats will be used to document this information.

The field logbooks will be signed and dated by the data recorder and will specify whether field methods and procedures were followed. Entries should be verified by a sampling team member other than the recorder, or by the FOM, who will perform a QA review and sign and date the logbook to document the review.

Backup photocopies of the field logbooks should be made and submitted to the project file. Sample collection and measurement information from the logbooks and data forms may be manually entered into the database and checked for accuracy. Entries should be verified by using double entry and comparing protocols. As necessary, the actual forms used will be modified to include the appropriate information codes to facilitate data entry. Completed logbooks and appropriate field forms will be submitted to the project file upon completion of the project.

At any point in the process of sample collection or data or document review, an NCR may be initiated if nonconformances are identified, and data entered into the database may be flagged accordingly. Additional information regarding NCRs is presented in Section 3.9.

4.4.3 Chain-of-Custody Documentation

Sample containers will be tracked from field collection activities to the analytical laboratory following proper chain-of-custody protocols and using standardized chain-of-custody forms.

When the samples are received at the laboratory, the laboratory receiving staff will check and document the condition of the samples upon arrival, check that the sample identification numbers on containers and chain-of-custody forms match, and assign laboratory sample identification numbers traceable back to the field identification numbers. Within 24 hours of receipt of the sample containers, the laboratory should send a LOR to the contractor Laboratory Coordinator or designee. This letter will provide the following information:

- Sample receipt date;
- Problems noted at the time of receipt;
- List of sample identification numbers and corresponding laboratory identification numbers for all samples received;
- Analyses requested for each sample received; and
- Completed cooler receipt checklists for each cooler received.

The LOR will be accompanied by the completed and signed chain-of-custody forms for the samples, and both documents will be submitted to the project file. Sample information recorded on the chain-of-custody form and in the LOR should be entered into the sample tracking database. This database will allow for tracking of the status of samples from the time of collection through analysis and validation. The database-tracking program should produce reports that will inform the project team of potential delays or problems related to sample analysis and validation.

4.4.4 Analytical Laboratory Document and Data Submission

Prior to release of a data package, the Laboratory Project Manager will review the data package for precision, accuracy, and completeness and should attest that it meets all data analysis and reporting requirements for the specific method used. The Laboratory Project Manager will then sign the hard copy forms certifying that the data package and any electronic format deliverables were reviewed and are approved for release.

Analytical results will be submitted to the contractor Laboratory Coordinator, or designee, on standardized forms in data packages in accordance with the scope of work for analytical services. These forms will contain results and required QA/QC information applicable to the analytical laboratory method used for analysis. In addition, as required by the scope of work, results of analyses will also be provided in electronic format on diskettes. The data coordinator receiving laboratory deliverables should make a copy of each data package and/or diskette and submit the originals to the project file. Results will be transferred to the database either electronically by diskette or manually from the hard copy into appropriate data tables within the database.

4.4.5 Data Verification and Validation

All data packages received from the analytical laboratory will be reviewed, evaluated, and validated by data management personnel. Screening data does not require validation. Details regarding the data verification and validation processes are presented in Section 3.0, and in the *Data Management Process for the St. Louis FUSRAP Sites* (SAIC, 1999).

With regard to data reduction, any replicate measurements associated with a single sample should be averaged prior to further data reduction. Correction of extreme (outlier) values will be attempted if the cause for the outlier value can be documented. This type of data will be corrected if the outliers are caused by incorrect transcription and the correct values can be obtained and documented from valid records. If the values can be documented as resulting from a catastrophic event or a problem in methodology, the values will be appropriately qualified. Documentation and validation of the cause of outliers will accompany any attempt to correct or delete these data values. Outlier values will not be omitted from the raw data reported to the USACE District, and valid values will be included in data summary tables. Analytical values determined to be at or below the detection limit will be reported numerically (e.g., </= 0.1 mg/L). The data presentation procedures will cite analytical methods used including appropriate detection limits.

4.4.6 Data Centralization and Storage

Once the data for a given sample or group of samples are complete and entered into the database, the data coordinator will check that logbooks, other field records, and all analytical data are complete and properly stored, including both the electronic form and associated data packages. Each piece of information will be documented as to its source, and hard copy information should be appropriately indexed and filed.

Procedure-based routines for establishing data security, backup, archival and maintaining proper database changes are also used to maintain database integrity. Classes of users should be defined with access levels approved and controlled by the Data Manager. Once loaded, the database will be secured from physical corruption (e.g., hardware or software failure) or from unauthorized access and illegal updating. Physical security requires recovery procedures, time stamping, and other related standard operating processes and controls. Any changes made to the completed database should be documented on standardized forms, which will be placed into the project file.

4.4.7 Data Summarization and Reporting

When field sampling has been completed and the analytical data have been received, validated, and transferred into the project database, the project report and QCSR will be generated. Information regarding the format and content for QCSRs is presented in Section 3.13. All analytical data will be reported at a minimum in accordance with FFA obligations. Specific reporting formats or requirements should be described in each WD (such as the EMG).

Project data will be screened for potential errors, compared to activity-specific WD background values and applicable regulatory limits, summarized in both tabular and graphical form to facilitate data interpretation. Data reduction and summation will be accomplished using quality-controlled and documentable reporting programs. Data summaries will be generally produced using predefined report formats available within the data management system. Statistical summaries should be generated by transferring data to an Statistical Analysis System (SAS) data set and adapting exiting data analysis programs to include project-specific aggregation or screening criteria. Any new programs developed under this project will be tested, reviewed, and documented as error-free following approved technical procedures. Data presented on maps, figures, or tables should be transferred electronically as far as possible to avoid introducing typographical errors.

4.4.8 Records Management and Document Control

Hard copies of all original site and field logbooks, chain-of-custody forms, data packages with analytical results and associated QA/QC information, data verification and validation forms, and other project-related information will be indexed, catalogued into appropriate file groups and series, and archived. Permanent record copies will be submitted to the designated records storage facility.

The Data Manager will archive the project data to the appropriate electronic media. A data archive information package will be prepared that describes the data system, file format, and method of archiving. Sufficient documentation will accompany the archived data to fully describe the source, contents, and structure of the data to ensure future usability. Computer programs used to manipulate or report the archived data will also be included in the data archive information package to further enhance the data's future usability.

4.4.9 Data Dissemination and the Web

A resource for dissemination of data from the project will be the St. Louis District FUSRAP web site. The web site will be secured with login and password to prevent unauthorized access to draft characterization data associated with the site. The web site may include the following principal components/capabilities: (1) description of characterization activities planned for the site; (2) a catalog of electronic photos taken at the site; (3) links to an ftp site to allow for the maintenance and transferal of large electronic files; (4) links to other, pertinent web sites such as those maintained by FUSRAP; (5) a list server that allows users of the site to post questions and concerns to project technical staff; (6) a place for the distribution of pertinent electronic copies of documents such as this SAG; (7) a place where graphics (e.g., maps, bore logs, etc.) and text produced by data analysis can be distributed; (8) a project data collection schedule that reports the progress of the data collection and sample analysis activities, including discrete samples, nonintrusive geophysical data, GWS/GPS data, and other data.

5.0 HANDLING OF INVESTIGATION-DERIVED WASTE (IDW)

All waste generated during field activities will be handled in bulk or drummed at the site for future disposal by USACE. Efforts will be made throughout the field program to minimize the volume of waste derived from sampling and decontamination procedures. Personnal protection equipment (PPE) from workers within radionuclide-contaminated areas should be handled as radiological waste.

IDW will be shipped to a commercial disposal facility, as necessary. Efforts to dispose of IDW in bulk, along with other wastes that may be generated during interim removal actions, will be encouraged. IDW will be managed, stored, and disposed in accordance with MDNR, EPA, and DOT regulations and requirements of the receiving facility and state.

6.0 HEALTH AND SAFETY

All field operations will be performed under the guidance and direction of a Site Safety and Health Officer (SSHO) who will ensure that, at a minimum, the health and safety requirements outlined in a Site-Specific Health and Safety Plan (SSHP) are implemented. The SSHP has been developed in accordance with EM 385-1-1, *USACE Safety and Health Requirements Manual* (USACE, 1996b) and Appendix B of ER 385-1-92, *Safety and Occupational Health Document Requirements for Hazardous, Toxic, and Radioactive Waste (HTRW) and Organic and Explosive Waste (OEW) Activities* (USACE, 1994a) and to meet the regulatory requirements of 29 CFR 1910.120 hazardous waste operations. Hazards of particular concern are generally in the following categories:

- Radiological hazards;
- Chemical hazards;
- Electrical hazards;
- Biological hazards; and
- Physical hazards.

The SSHP will also identify responsible personnel, required training for working on-site, PPE requirements, medical surveillance requirements, monitoring requirements, site control measures, decontamination procedures, contingency plans, and other information necessary to implement worker safety depending on the activities planned for the site.

Decontamination procedures may vary depending upon the method of collection and the parameters for which samples will be analyzed. Decontamination will be conducted in accordance with approved contractor procedures.

7.0 REFERENCES AND BIBLIOGRAPHY

ASTM (American Society of Testing and Materials) 1996. *Annual Book of ASTM Standards*, Volume 04.08, Soil and Rock.

DOE (United States Department of Energy), 1990a. *Federal Facility Agreement in the Matter of: The United States Department of Energy, St. Louis and Hazelwood, Missouri*, Docket No. VII-90-F-0005. June.

DOE, 1990b. *Radiological, Chemical, and Hydrogeological Characterization Report for the St. Louis Downtown Site in St. Louis, MO, Revision* 1, Prepared by Bechtel National, Inc., DOE/OR/20722-258, Oak Ridge, TN. September.

DOE, 1991. *Work Plan for the Remedial Investigation/Feasibility Study-Environmental Impact Statement for the St. Louis Site, St. Louis, Missouri,* Prepared by Bechtel National, Inc., DOE/OR/21949-271.1. December.

DOE, 1994a. *Remedial Investigation Report for the St. Louis Site, St. Louis, Missouri,* Prepared by Bechtel National, Inc., DOE/OR/21949-280. January.

DOE, 1994b. *Feasibility Study/Environmental Impact Statement for the St. Louis Site, St. Louis, Missouri*; DOE/OR/21950-130, United States Department of Energy; Oak Ridge Operations, Oak Ridge, Tennessee. April.

DOE, 1995. *Remedial Investigation Addendum for the St. Louis Site, St. Louis, Missouri,* DOE/OR/21950-132. September.

DOE, 1997a. *St. Louis Airport Site (SLAPS) Interim Action Engineering Evaluation/Cost Analysis (EE/CA), St. Louis, Missouri*, DOE/OR/21950-1026. September.

DOE, 1997b. *Evaluation of Radiochemical Data Usability*, Prepared by Lockheed Martin Energy Systems, Inc., ES/ER/MS-5. April.

Environmental Protection Agency (EPA), 1986a. *NEIC Policies and Procedures*. United States Environmental Protection Agency Office of Enforcement and Compliance Monitoring. EPA 330/9-78-001-R. May 1978. Revised, May.

EPA, 1986b. *Guidelines for Groundwater Classification under EPA Groundwater Protection Strategy*. Final Draft, December.

EPA, 1987. *Data Quality Objectives for Remedial Response Activities*, Remedial Response and Office of Waste Programs Enforcement; Washington, D.C., EPA/540/G-87/003.

EPA, 1989. *National Priorities List, St. Louis Airport/Hazelwood Interim Storage/Futura Coatings Co.,* St. Louis County, Missouri, NIL-U8-2-6-10/89. October.

EPA. 1991. *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans,* QAMS-005/80.

EPA, 1993a. *Data Quality Objectives Process*, EPA-540-R-93-071. September.

EPA, 1993b. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition, Revision 1, Updates 1, 2, and 3.

EPA, 1994a. *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations*, EPA QA/R-5. January.

EPA, 1994b. *EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, EPA-540/R-94/012. February.

EPA, 1994c. *EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA-540/R-94/013. February.

EPA, 1994d. *Guidance for the Data Quality Objectives Process*, EPA QA/G-4. September.

EPA, 1995. *Record of Decision*; Marine Corps Air Station; Yuma, Arizona, USEPA Region IX.

EPA, 1997. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, NUREG-1575, EPA 402-R-97-016. December.

Federal Emergency Management Agency (FEMA), 1983. *Flood Insurance Rate Map, City of Hazelwood, St. Louis County, Missouri*, Community-Panel No. 290357-0005-6. January.

Robbart, Jr., and Johnson, R., 1996. *Adaptive Sampling and Analysis Programs for Soils Contaminated with Explosives, Case Study: Joliet Army Ammunition Plant,* Environmental Technology Division, Army Environmental Center, Aberdeen Proving Ground, Maryland.

SAIC, 1999. *Data Management Process for the St. Louis FUSRAP Sites, St. Louis, Missouri.* Final, July.

USACE (United States Army Corps of Engineers), 1994a. *Safety and Occupational Health Document Requirements for Hazardous, Toxic, and Radioactive Waste (HTRW) and Organic and Explosive Waste (OEW) Activities*; Appendix B: Safety and Health Elements for HTRW and OEW Documents, ER 385-1-9. March.

USACE, 1994b. *Monitor Well Design, Installation and Documentation at Hazardous and/or Toxic Waste Sites, Engineer Manual,* EM 1110-1-4000. August.

USACE, 1994c. *Requirements for the Preparation of Sampling and Analysis Plans*, Engineer Manual, EM 200-1-3. September.

USACE, 1996a. *Engineering and Design – Soil Sampling,* Engineer Manual, EM-1110-1-1906. September.

USACE, 1996b. *Safety and Health Requirements Manual*, EM-385-1-1. September.

USACE, 1997. *Environmental Quality – Chemical Quality Assurance for Hazardous, Toxic, and Radioactive Waste (HTRW) Projects*, Engineer Manual, EM-200-1-6. October.

USACE, 1998a. *Groundwater Characterization Report of 1997/1998 Baseline Data for the St. Louis Downtown Site, St. Louis, Missouri*, USACE/OR/DACW45-1050. July.

USACE, 1998b. *Record of Decision for the St. Louis Downtown Site, St. Louis, Missouri.* October.

USACE, 1998c. *Groundwater Characterization Report of 1997 Baseline Data for the St. Louis Airport Site (SLAPS), St. Louis, Missouri*, USACE/OR/DACA62-1040. May.

USACE, 1998d. *Engineering Evaluation/Cost Analysis (EE/CA) and Responsiveness Summary for the St. Louis Airport Site (SLAPS), St. Louis, Missouri.* May.

USACE 1998e. *Engineering and Design – Chemical Data Quality Management for Hazardous, Toxic, and Radioactive Waste Activities*, Engineer Regulation, ER-1110-1-263. April.

USACE 1999a. *Potential Contaminants of Concern Assessment Memorandum (PAM), St. Louis, Missouri.* March.

USACE, 1999b. *Environmental Monitoring Guide for the St. Louis Sites, St. Louis, Missouri.* December.

APPENDIX A

SCREENING PROCEDURES

Appendix A

Screening Technologies to be Used at St. Louis FUSRAP Sites

Radiological Screening

Radiological screening for characterization generally includes gross counts reported in disintegrations per minute (dpm) or counts per minute (cpm) in the following situations:

- walkover survey surface measurements,
- downhole logging in shallow or deep soil borehole,
- in-spoon, -auger, or -bowl surface measurements of the soil core (if downhole is not used),
- clothing, equipment and building surface measurements,
- swipes of transferable contamination.

The walkover, downhole and in-spoon screening measurements are used to determine if or when quantitative isotopic-specific analyses may be performed. Initial radiological surface boundaries established by walkover survey will be confirmed by in-situ gamma spec and intrusive samples and on-site laboratory gamma-spec analysis or off-site alpha-spec analysis. Since in-situ radiological measurements are surface by nature, downhole logging of boreholes will indicate which intervals below the ground surface exceed the investigative action levels (IAL). All borehole intervals are containerized. Each interval is screened and quantitative analyses are performed on the intervals with the highest screening measurement, the deepest interval exceeding the IAL and the next interval not in exceedance. Thus, a vertical boundary is initially established with screening and confirmed with laboratory analyses. For boreholes in which screening indicates that all intervals are below radiological IALs, the interval with the highest downhole or in-spoon screen is sent for laboratory confirmation. Intervals not analyzed will be archived and available for further analyses if necessary. In-spoon, -auger, or -bowl measurements are used if cave-in or water in the borehole prevents downhole logging. This surface screening measurement is performed along the soil-filled split-spoon when it is retrieved on the surface, after the soil in a hand auger interval is retrieved, or after mixing the soil interval in the bowl. Note that in-bowl mixing may result in additional exposure to airborne particles and may be discouraged in the field for health and safety reasons.

Subsurface gamma scanning and in-situ gamma spec techniques are sensitive to both surface and shallow subsurface gamma sources. The depth is dependent on the energy of the emitted gamma and may range from virtually the surface for low energy gamma rays to approximately 1 foot for high energy. FIDLER-based instruments are tools for low energy gamma surface detection.

Geophysical Screening

Intrusive subsurface soil sampling with hand augers or split spoons from a drill rig, will be based on non-intrusive geophysical surface screening. The geophysical surveys for fill areas and buried metallic objects will be comprised of electromagnetic (EM) surveys and ground-penetrating radar (GPR). Underground utility clearance will use a magnetometer (Radiodetection RD400) in conjunction with careful field checking of available plat sheet information prior to intrusive soil sampling. The EM survey and GPR will be performed to identify primary fill area perimeter boundary characterization. EM methods are used to detect measurable secondary electromagnetic fields caused by conductive bodies (metallic or non-metallic) that have been subjected to a transmitted (primary) electromagnetic field. EM surveys are impeded by chain-link fencing, above-ground piping, and overhead electric power lines. Experience has shown that two EM instruments yield the most useful information:

- Geonics EM-61 - a metal detector capable of detecting a single 55 gallon drum at a depth of over 10 feet beneath the instrument; and
- Geonics EM-31 - a ground conductivity detector with an effective depth of exploration to about 6 meters.

A discussion of EM and GPR theory, along with specific details of operation, are included in this appendix as Attachment 1.

Soil Gas Screening

Screening soil gas vapors for volatile organics is a good way to detect subsurface sources of volatile organic contaminants. The two types of soil gas screening collection methods generally used are active and passive systems. Active soil gas screening involves direct removal of a soil gas sample in-situ, while passive soil gas screening involves the adsorption of volatile organic compounds (VOCs) onto a medium over time. The passive soil gas screening technique is proposed at SLAPS since it may be more sensitive and can take advantage of peak soil gas emitting periods of time. The field procedures that are proposed for collection of passive soil gas samples at SLAPS are described below:

- One or more two-person teams transport the passive soil gas collection media to the site and deploy them on a prearranged survey plan or grid. One team member is designated as "clean" and protects system components from contamination.

- At each sampling location, a hole is made in the ground surface by hammering a metal rod about three inches into the soil. The team then removes the shipping cap from the collector vial which contains the adsorbent media and replaces it with a sampling cap which allows vapors to enter. The vial is then inverted and inserted into the hole in the ground. The top of the hole is then backfilled with natural soil materials, and the sampler is allowed to adsorb VOCs for a period of several days.

- Quality control ambient air samples are also collected in the field to account for any background conditions.
- All collectors are retrieved after three days of deployment. Shipping caps are replaced, and the sample vials are labeled and shipped to the laboratory for analysis.
- At the laboratory, each sample media is desorbed and then analyzed by gas chromatography (GC) or GC/mass spectroscopy (MS) methods.

ATTACHMENT 1

THEORY, LIMITATIONS, AND PROCEDURES FOR ELECTROMAGNETIC TERRAIN CONDUCTIVITY AND GROUND-PENETRATING RADAR

ELECTROMAGNETIC TERRAIN CONDUCTIVITY
THEORY, LIMITATIONS, AND PROCEDURES

INTRODUCTION

Electromagnetic terrain conductivity (EM) is an induction method of evaluating the electrical properties of the subsurface. Induction methods require no intrusive activities and are conducted using appropriately-sized high frequency transmitters and receivers. Data can be collected nearly as quickly as the operator can walk along the ground surface; therefore, this technique is well suited to conduct regional and/or reconnaissance-type surveys to delineate areas warranting additional, more detailed investigation.

Theory

Like all EM methods, electrical conductivity (terrain conductivity) surveys utilize the principle that a magnetic field can be created by a changing electric field and that an electric field can be created by a changing magnetic field. When this technique is utilized, a time varying primary magnetic field is induced by passing an audio-frequency alternating current through a transmitting coil. If conductive material is present, this primary field in turn induces "eddy" currents (see attached figure) which flow in closed loops normal to the direction of the magnetic field. The magnitude of these "eddy" current loops is directly proportional to the conductivity of the earth in that vicinity.

The "eddy" currents, in turn, induce a secondary magnetic field of proportionate strength. The phase of the secondary field may differ from that of the primary field, and the strength will typically be much less. The resultant total magnetic field (primary and secondary) produces an output voltage within a receiving coil which has been placed a fixed distance away. With constant coil spacing and orientation, the primary field has constant intensity. Thus, any variations in the total magnetic field are related only to the conductive materials in the subsurface.

Most rocks and soils are electrical insulators of very low conductivity. In general, the subsurface conductivity that is being measured during an electrical conductivity survey is electrolytic, and takes place through moisture-filled pores and passages within the subsurface. Therefore, the conductivity in the subsurface will be directly proportional to the porosity, permeability, moisture content, temperature, concentration of dissolved electrolytes, and the composition of colloids present in the soil and rock matrix.

Two different parts of the induced magnetic field are measured by Science Applications International Corporation (SAIC). The dominant phase of the induced magnetic field from normal earth materials is 90 degrees out of phase with the primary field, hence the name quadrature phase. The quadrature phase of the induced magnetic field can be mathematically shown (McNiel, 1980) to be linearly related to the ground conductivity and is normally referred to as simply the apparent conductivity. When abnormally high conductivity materials are present (such as buried metals), the part of the induced magnetic field which is in-phase with the primary magnetic field becomes more dominant. The in-phase component of the induced magnetic field is therefore used to determine the existence of abnormally good subsurface conductors, such as buried metals. These data are normally presented in parts per thousand (ppt) of the primary field strength. The apparent conductivity data is measured in millimhos per meter (mM/m) or millisiemen per meter (mS/m), which is the inverse of resistivity, which is normally measured in ohms per meter.

In some instances, it is useful to vary the dipole (transmitter and receiver antenna coils) orientation to be horizontal or vertical. By changing the orientation, the subsurface may be investigated in different ways. The horizontal dipole orientation is very near-surface sensitive, and 70 percent of the secondary magnetic field strength originating from the first 9 feet of the subsurface (0.75 times the intercoil spacing of 12 feet). The vertical dipole orientation discriminates against the near surface, with the greatest sensitivity being 4.8 feet into the subsurface (0.4 times the intercoil spacing). With the vertical dipole orientation, 70 percent of the secondary field strength originates from the first 18 feet of the subsurface (1.5 times the intercoil spacing).

Limitations

The terrain conductivity is dependent upon the nature of the soil; subsurface porosity; permeability; moisture content; concentration or lack of concentration of dissolved electrolytes and colloids; and the presence of interferences such as electric lines, pipes, buildings, buried metal, and foundations. Thus, the actual magnitude of conductivity values measured does not always indicate a specific geologic condition. What is important are the trends and anomalies in the measurements. These lead to a qualitative interpretation of the data. Toward this end, SAIC personnel are highly experienced in the interpretation and evaluation of EM data. To be quantitatively meaningful, the survey results must be correlated with the results from confirmatory test borings, test pits, or other secondary evaluation techniques.

Equipment

The primary tool to be used for data acquisition at this site will be an EM terrain conductivity meter Model EM-31DL, by Geonics Limited of Mississaugua, Ontario, Canada. This one-man instrument has the transmitter and receiver permanently imbedded at either end of a boom which is connected to a console box carried on the operator's hip. In this fashion, the operator is able to monitor instantaneous changes in terrain conductivity as well as adjust monitoring scales.

To facilitate data handling, information from each survey station will be recorded on a data logger. This unit, also carried by the operator, records line, station, and the two phases of conductivity data for subsequent evaluation.

A hip chain will be used to measure the in-line distance to assist in assuring the repeatability and location awareness of any geophysical information gathered. The hip chain operates by measuring the length of biodegradable thread that is drawn from a spool within the instrument. A direct reading counter of in-line distance is built into the unit to track the current location. The units are typically accurate to within one percent of the total traverse distance.

Protocol

At the initiation of each day's surveying, the EM-31DL will go through a complete function check to assure proper operating conditions. The operator will catalog the date, time, operator identification initials, site identification, line number to be surveyed first, starting station, and station increment into the data file.

The end points of the survey traverses will be marked in such a fashion that the operator will be able to start at one marker and walk toward the second target. These markers will consist of wooden stakes or push flags driven into the ground or bits of flagging placed on nearby trees or fencing. Utilizing the hip chain for in-line distance and knowledge of the location of the survey traverse end points, all geophysical data can be located with reasonable accuracy. In the event that a line of sight is not available from one end of the traverse to the other, or an abnormally long traverse is necessary, a set of mid-traverse markers will be established to assist in survey location accuracy.

The survey will be conducted with the operator monitoring the quadrature phase (conductivity) component of the data to ensure proper scale and equipment orientation. Typically, the transmitter/receiver boom is oriented along the in-line axis. In the event that an obvious cultural interference is encountered, such as a fence, utility, or drain pipe, the boom will be rotated until the interference reached a minimum. When the operator is satisfied that the conductivity of the station being surveyed represented subsurface conditions, the information for the in-phase and quadrature phase segments of the data will be transmitted to the data logger. During the course of the traverse, when a physical marker or anomaly is apparent, the operator will be able to make note of the feature in the data file stored within the data logger. This permanent record will be available for future reference. When this is completed, the operator will move to the next survey station location, typically 10 feet away. In the event of high winds, a helper will attempt to minimize in-line distance distortions by weighing down the hip-chain string with available sticks, stones, and rocks.

At the conclusion of the day, all data collected will be down-loaded from the data logger to a personal computer. These data will be plotted in tabular form for reference and profiled for initial interpretation and evaluation. All traverses will be marked on a base map utilizing reference comments collected in the field and recorded in the data logger.

By down-loading, printing, and profiling the data daily, quality assurance can be maintained with a guarantee of data availability. By reviewing and performing an initial interpretation of the data, additional surveying can be planned to encompass any unusual findings brought to light by the survey. In this fashion, if additional data appear to be necessary, or an unaccountable anomaly is present that needs to be resurveyed for verification, these activities can be planned and performed.

During the course of the traverse, the vertical dipole orientation will always be recorded. At sites where depth-discriminatory information is believed to be useful, horizontal dipole orientation data will be collected. The horizontal dipoles will be obtained by rotating the equipment around a horizontal plane at the operator's side. In all dipole orientations, both the in-phase and quadrature phase of the data will be recorded.

Interpretation Considerations

The horizontal and vertical dipole orientations of the EM-31DL result in two different views of the subsurface. The vertical dipole orientation discriminates against near-surface anomalies and has 70 percent of its signal response within the first 18 feet of the subsurface (1.5 times the intercoil spacing of 12 feet). The horizontal dipole data are near-surface sensitive, with 70 percent of its signal returned within the first 9 feet of the subsurface (0.75 times the intercoil spacing of 12 feet). By observing the similarities or the differences between the horizontal and vertical dipole data sets, a vertical sense of the subsurface can be gathered.

Conductors in the subsurface dramatically increase the conductivity measured. Information about the conductors (metals) in the subsurface can be estimated by close inspection of the in-phase responses and recognition of magnetic field spacial response patterns. Shallow or high mass objects will have a significant effect on both the apparent conductivity and the in-phase response of the subsurface. Because of the vortex current shape of the primary magnetic field and the normal magnitude of the secondary magnetic field, the in-phase data quality typically decays rapidly with depth. Due to current gathering phenomenon within a limited mass conductor (buried metal) at depth, the in-phase response may not be apparent, while a significant quadrature phase (apparent conductivity) response is observed.

Since metals are not normally considered a natural part of the subsurface, the electronics of the instrumentation respond in a unique fashion. The apparent subsurface conductivity, as measured by equipment, ceases to correlate with the true conductivity of the subsurface at approximately 100 mM/m. While the electronics of the instrument allow for conductivities up to 300 mM/m to be measured, the true conductivity is actually less than the measured conductivity at this level. A quirk in the electronic configuration allows for all conductivities greater than 300 mM/m to appear as negative conductivities. Experience shows that negative values of conductivity often represent metals in the subsurface. Although it is technically incorrect to present negative conductivity values, the availability of this information provides a rapid interpretive tool with relatively high accuracy.

It has been shown in the public literature (Saunders et al, 1983; Gemeroth and Schmerl, 1987; Valentine and Kwader, 1984) that under the proper setting, organic compounds can be detected through the use of the EM-31DL. Experience has shown that organic contaminants tend to elevate or suppress the natural conductivity (quadrature phase of the data) of the subsurface, depending on the setting. Organic contaminants, which have very low dielectric constants, tend to mask the natural conductivity of the subsurface. However, empirical evidence exists showing that, under some circumstances, the opposite is true. The theoretical foundations for this occurrence have not yet been explained, and the subject remains under debate within the scientific community. SAIC has found that there is no response on the in-phase segment of the data set, regardless of the quadrature phase response. Many data analysts attempt to look only at the shape of a data set and its relative magnitude. Often, potential organic compound anomalies can be identified by observing the relationship between the in-phase and quadrature phase of the EM wave field in comparison with the relative response patterns shown in the data sets.

EM-61 HIGH-SENSITIVITY METAL DETECTOR

Introduction

The EM-61 high sensitivity metal detector is able to discriminate between conductive earth materials and highly conductive metallic targets such as underground storage tanks (USTs), drums, and buried metallic waste.

Principles

The EM-61 generates 150 EM pulses per second and measures during the off-time between pulses. After each pulse, secondary EM fields are induced briefly in moderately conductive soils and for a longer time in metallic objects. Between each pulse, the EM-61 waits until the response from the conductive earth dissipates and then measures the prolonged buried metal response. By sensing only the buried metal response, the EM-61 detects targets that might otherwise be missed. Conventional inductive metal detectors are generally limited in depth of exploration due to design factors idealized for detecting small objects at shallow depths. The EM-61 can distinguish near-surface metals from metal objects buried at depths by using two separate coils. The design of the second coil is such that the near-surface response can be made virtually zero, increasing the detection of deeper targets.

Instrumentation

The EM-61 system consists of a backpack, polycorder, and a two-coil assembly which can be towed on wheels behind the operator or carried around the operator using a harness. The coils are connected to each other by an interconnecting cable and are both connected to the backpack. The entire system is run from the polycorder which is also attached to the backpack. System power comes from a 12-volt rechargeable battery attached to the backpack.

Field Design

In order to collect the highest quality data using the EM-61 high sensitivity metal detector, the proper procedures should be followed. Survey lines will be marked with flags or paint before the survey begins. All lines will be parallel or perpendicular and a fixed distance apart. Every EM-61 survey will involve estimating target characteristics and setting up the EM-61 system. Target characteristics will affect the length of the survey lines. Target characteristics will include:

1. Depth range of target(s).
2. Lateral and vertical dimension of target(s).
3. Metal content of subsurface materials in area of investigation soils with a high metal content will decrease ability to clearly detect a single metallic object.

In order to assure the highest quality data, the EM-61 assembly must be properly set up.

Data Collection

Actual data will be acquired by towing the EM-61 assembly along pre-marked survey lines at a normal walking speed. Each record will be annotated at previously marked regular increments along the survey line (5 feet, 10 feet, or 20 feet depending on line length) and at any notable point along the line (e.g. surface metallic objects, line direction change, and change in surface characteristics).

Data Analysis

EM-61 data are relatively simple to display and analyze. Two channels of secondary responses in mV are measured by the coils. One channel responds to near-surface metal, while the other channel responds to deeper metallic objects. The effects of near-surface metallic objects can thus be subtracted from the readings. Data can be inspected in cross-sections or contour map form. Peaks in the data show the location of metallic objects, ferrous or nonferrous. Target depths can be approximated from the profiles.

Data Presentation

Although the presence of some highly metallic features in the subsurface may be apparent during data collection, all data should be transferred from the polycorder to a PC for viewing. Only then can the differential between the two channels of the EM-61 be viewed. Data will be downloaded to a PC in the field, and subsurface features observed in the survey area may be marked with flags or paints if requested by the client. Paper plots of the data along with interpretation of feature's approximate depth and dimensions in the subsurface will be included in a report as per client request.

GROUND-PENETRATING RADAR

Introduction

Ground-penetrating radar (GPR) is useful in locating and identifying features buried below grade level (bgl). GPR is most commonly used to determine the location and sizes of underground storage tanks (USTs) or to determine the presence of buried drums and landfilled areas.

Principles

GPR systems produce cross-sectional images of subsurface features by transmitting discrete radar pulses into the subsurface and recording the echoes or reflections from interfaces between materials with differing dielectric properties. In principle, GPR is entirely analogous to a medial sonogram or ultrasound, except that GPR uses electromagnetic (radar) energy rather than acoustic (sound) energy and is therefore sensitive to electrical properties (as opposed to ultrasound which is sensitive to densities).

Cross-sectional images of subsurface objects and layers are generated by rapidly and repeatedly transmitting radar pulses into the subsurface as the GPR transmitter and receiver are towed along a survey profile (commonly at a small and fixed separation). For each pulse, the reflections from subsurface dielectric contrasts are recorded by the receiving antenna as wiggle traces of amplitude vs. travel time. The wiggle traces are recorded on a strip chart by setting a print threshold. For reflections with amplitudes greater than the print threshold, the strip chart plots a black mark at the two-way travel time for the reflection. Successive reflections are plotted side by side on the record and produce a cross-sectional image of the electrical variations in the subsurface.

More distinct and sensitive cross-sectional images can be plotted by assigning a color scale to the amplitudes of reflected pulses. This produces color radar records which depict both high amplitude reflections (above the print threshold for a black and white record) and low amplitude reflections that are not recorded on a black and white record (because they are below the print threshold). Therefore, on a color record, it is possible to determine not only the depth to a particular reflector, but also the amplitude of the reflection.

Reflection amplitudes are dependent on the magnitude of the dielectric contrast at depth. Since the electrical properties of most soils and metal tanks or pipes are dramatically different, these targets produce dramatic and characteristic reflections which can be easily recognized on a color radar record (see enclosed records). Concrete, fiberglass, and plastic pipes, as well as tanks and other restructures, also produce recognizable reflections. These reflections are, however, more subtle reflections since they have electrical properties that more closely match many soils. Terra cotta pipes are often difficult to recognize since the electrical properties of terra cotta (clay) are very close to many clay-rich soils. Reflections are also obtained from naturally occurring electrical interfaces such as soil/bedrock, soil/air, bedrock/air, dry soil/saturated soils (e.g., the groundwater table), and other subsurface contacts.

The effective penetration depth of radar systems is controlled by the dielectric permittivity and electrical conductivity (usually dictated by moisture content) of the soils and the frequency of the radar energy. For a given radar frequency, a coherent pulse will travel more deeply into less conductive materials. In highly conductive materials (such as damp clays), the pulse is dissipated at very shallow depths (sometimes measured in inches). Penetration can be increased by using a transmission antenna with a lower frequency, but this causes a loss of resolution. Frequencies commonly employed fall within the 80 to 900 MHz range. In general, the use of GPR is limited to depths of 15 feet or less (although, in very dry sand or bedrock, penetration depths of up to 30 feet have been obtained).

Resolution of GPR systems is dependent on the frequency of the antenna employed. Very high frequency antennas (900 MHz or greater) can resolve features one-quarter inch or less in diameter (e.g., reinforcing rods) but penetrate to depths of only one or two feet. The most commonly used antennae (designed for optimum transmission at frequencies of 120 to 500 MHz) can resolve linear features with dimensions as small as one or two inches, at penetration depths up to 10 feet (e.g., utility lines).

Since they produce cross-sectional images, GPR records are usually interpreted visually, often in real time. In the absence of a feature with known depth on the record, an absolute depth scale is unavailable, and only relative depth information can be obtained. However, if a feature with a known depth can be scanned, its position on the record establishes an empirical absolute depth scale.

Since the GPR antenna is towed at a sometimes uneven speed, positioning along the record is achieved by placing event marks on the record at known locations or spacings along the profile.

Instrumentation

Data will be recorded using a GSSI SIR-2 system which allows GPR data to be viewed on a color monitor using various transforms and printed out in black and white. GPR data will be digitally recorded by the SIR-2. In the event that further processing of GPR field data is necessary, digitally recorded data will be transferred to an office PC where RADAN processing software can be used.

Field Design

Field design will involve the following aspects: estimating target characteristics and selecting appropriate antenna.

Target Characteristics

Target characteristics will affect the choice of antenna and length of survey lines. Target characteristics will include:

1. Depth range of target(s).
2. Lateral and vertical dimensions of target.
3. Definition of target(s) boundaries.
4. Subsurface materials in area of investigation.

5. Electrical conductivities of subsurface materials and target(s).

Antenna Selection

Center frequencies for antennas to be used are 200, 500, and 1,000 Mhz. The antenna of choice for each survey will depend upon two factors: maximum target depth and target size. The lower frequency antennas provide greater depth of penetration but lower resolution.

Data Collection

In order to assure the highest quality data, the SIR-2 system must be properly set up. Data collection procedures include conducting preliminary test lines, estimating subsurface velocity, and finally acquiring the data.

Conducting Preliminary Test Lines

When preparing to survey preliminary lines, the user should measure off a known distance along the proposed traverse within the survey area. The lines should be marked off the line at regular increments with flags or paint (5, 10, 20 feet, depending on traverse length) to keep track of position along line. (Note: GPR data are less useful if horizontal position along line is not known.) The printer is set to remote mode so the system can be run from the antenna. The button on the antenna handle is clicked to start the system. The antenna is pulled along a line at a rate of two to three miles per hour (mph) (normal walking speed). The antenna button is clicked as the antenna crosses each marked point, as this will annotate the record with event markers. When the end of the line is reached, the antenna button is held down for approximately three seconds to shut off system.

If the position of an object of known depth similar in characteristics to target(s) is known, preliminary lines should be conducted over this object. This will give user an idea of GPR's ability to show target(s) and subsurface velocity.

Estimating Subsurface Velocity

To determine an approximate depth of features appearing on GPR profiles, a subsurface velocity (two-way slowness) must at least be estimated. The closer the estimate to the actual subsurface velocity (two-way slowness), the more accurate the depth determination will be. If the GPR cannot be pulled over objects of known depth in survey area, then the user must estimate subsurface velocity (two-way slowness) based on velocities characteristic of the subsurface materials. The estimated subsurface velocity is reported on a GPR data acquisition log.

Acquiring the Data

Actual data should be acquired in the same manner as the preliminary data but only after the preliminary tests have been conducted. When acquiring data, the strain relief clip must be attached to the antenna and the antenna must never be dragged over the cable when surveying. The record is annotated with fiducial markers at regular increments and at any notable point along a line (e.g., surface features, line direction change, and change in surface characteristics). All GPR data will be digitally recorded in the event that further computer processing will be necessary. Comments and digital data information are recorded on the GPR field acquisition log.

Data Analysis

Primary interpretation of GPR field data will be done from the color field monitor and paper records printed in the field. In cases where targets are not field resolvable, digitally recorded data will be processed utilizing processing capabilities in the SIR-2. Data manipulation will often allow increased resolution of weak or unclear images spotted during field acquisition.

APPENDIX B

MDNR-DGLS ANNULAR SEAL AND DECOMMISSIONING GROUT VARIANCE

Forwarded to Environmental
5/12/00

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
9170 LATTY AVENUE
BERKELEY, MISSOURI 63134

May 9, 2000

RECEIVED MAY 15 2000

Mr. Evan Kiefer
Well-head Protection Section, DGLS
Department of Natural Resources
P.O. Box 250
Rolla, MO 65402-0250

Subject: Request for Variance for Annular Seal and Decommissioning Grout

Dear Mr. Kiefer:

The Corps of Engineers is the responsible government agency for accomplishing remediation of properties in the Formerly Utilized Sites Remedial Action Program (FUSRAP) properties. The Corps is seeking a variance for the 10 CSR 23-4.060 (11) (D) type of grout to be applied across the St. Louis FUSRAP sites in St. Louis City and County, Missouri. The MDNR-DGLS contact for FUSRAP is Mr. Joe Gillman.

The cement-slurry recommended by the state has 2% to 6% by weight of Bentonite. The Corps is interested in using two hydraulic grouts that have properties of both cement slurry without Bentonite and Bentonite slurry without cement. The one mix have properties of a gel that does not set, which avoids cracking, but has a strength comparable to soils. The second grout has a considerable strength relative to soils but would only be used in locations with strength requirements, in slopes or near levees.

The proposed, soil-matching grout would have 1 to 1-1/4 pound unaltered Bentonite powder to each gallon of water mixed well before adding 2 pounds of Type I Portland cement (per gallon of water) [ASTM D 5092-90]. The proposed, strength grout consists of 94 pounds of Type I Portland cement, 20 pounds of improved Bentonite, and 15 gallons of water. The proposed grout mixes may be used both as an annular seal for new monitoring wells and as the closure grout for decommissioning wells being removed.

Please respond to our variance request by letter or fax. Should you have any comments or questions regarding this letter, please feel free to contact Dr. Greg Hempen at (314) 524-7389 [fax, (314) 524–7310].

Sincerely,

Sharon Cotner

Sharon Cotner
FUSRAP Program Manager

STATE OF MISSOURI
Mel Carnahan, Governor • Stephen M. Mahfood, Director

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGY AND LAND SURVEY
P.O. Box 250 111 Fairgrounds Rd. Rolla, MO 65402-0250
(573) 368-2100
FAX (573) 368-2111

ROBERT E. ARCHER

pg 1 of 1

VARIANCE: Approved **VARIANCE NUMBER:** 1485

WELL OWNER INFORMATION

NAME: US Army Corps of Engineers Greg Hempen
ADDRESS: 9170 Latty Ave **FAX:**
CITY: Berkeley **STATE:** MO **ZIP:** 63134- **TELEPHONE:** (314) 524-7389

WELL LOCATION

COUNTY: St. Louis **LAT.** 0 0 0 **LONG.** 0 0 0
1/4 1/4 1/4 **SEC.** 0 **TWN.** 0 N **RNG.** 0

CONTRACTOR INFORMATION

COMPANY NAME: Various **PERMIT NUMBER:**
CONTRACTOR NAME:
ADDRESS: **FAX:**
CITY: **STATE:** **ZIP:** **TELEPHONE:**

VARIANCE INFORMATION

VARIANCE EXPLANATION

Variance granted to install monitoring wells at the St. Louis FUSRAP site (SLAPS, SLDS, HISS, and SLAPS vicinity property) by using a grout material that has a different percentage of cement and bentonite than required in the regulations (see attached letter).

RULE NUMBER MODIFIED: 10 CSR 23-4.060

REASON FOR VARIANCE

The proposed grout will be used to match the soil in the area where the wells are to be installed.

DATE APPROVED: 5/24/2000 **BY:** Scott W Kaden Scott W Kaden
COPY SENT TO OWNER (DATE): 5/25/00 **BY:** ndh
COPY SENT TO CONTRACTOR (DATE): **BY:**

RECYCLED PAPER

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